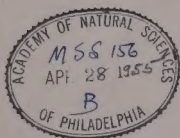


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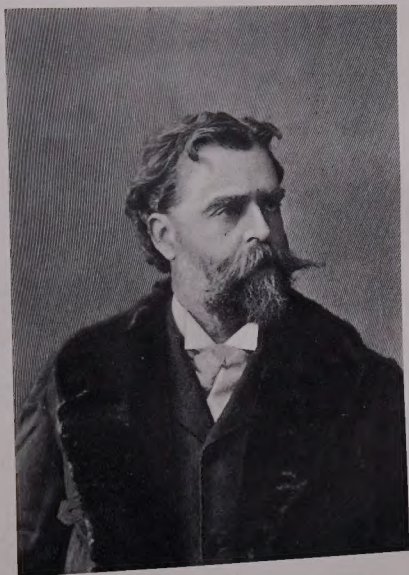
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Yours very truly
Robt. H. Lamborn

BIOGRAPHICAL NOTICE OF ROBERT HENRY LAMBORN.

BY CARRIE B. AARON.

At Hornblow Hill, Chester county, Pa., not far from the historic Kennett, whose beauties have been the theme of Bayard Taylor's pen, Robert Henry Lamborn was born, October 29, 1835.

His boyhood was spent in the home of his fathers, and he was thus surrounded by the advantages of inherited prosperity. His father was a member of the Society of Friends, and was an intelligent man of refined tastes, a close observer, a bright conversationalist and a wide reader. The son inherited his prepossessing appearance, courteous manner, dignified bearing and agreeable disposition.

Young Lamborn's education was given a scientific turn by the influence and patronage of his uncle, Jacob Pierce, who served as Librarian of the Academy of Natural Sciences of Philadelphia from December, 1817, to December, 1826, and who, in the early days of the institution, had, at one time, all its collections stored in one of his spare back rooms. No doubt the youth received his first inspiration for "collecting" while in such environment.

After receiving a common-school education and a special training at the Polytechnic College in Philadelphia, he determined to continue his studies in civil engineering abroad. He secured means to do so by the publication of original essays on the metallurgy of copper, silver and lead,¹ works which, although long superseded, were considered ably written and used as text-books both here and abroad. He became a student of the Royal Saxon Mining Academy of Freiberg, and the School of Mines in Paris, graduating from the University of Giessen, from which he later received the degree of Doctor of Philosophy.

Soon after the outbreak of the Civil War, Dr. Lamborn returned from Europe and joined the army, serving with the Anderson

¹ A Treatise on the Metallurgy of Copper, J. Weale, London, 1860, and A Treatise on the Metallurgy of Silver and Lead, J. Weale, London, 1861.

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Cavalry at the Battle of Antietam, under Captain Palmer. He became captain on the staff of Gen. John F. Reynolds in 1862.

After the war he was twice elected City Surveyor of Trenton, N. J. He was engineer in charge of fuel and iron rails on the Pennsylvania Railroad when coal was displacing wood as fuel for engines, and steel was finally supplanting iron. He was Secretary of the American Iron and Steel Association at the period of its development into an institution of national importance, and when the publication of iron and steel statistics became a necessity. He was Secretary, Treasurer and Director of the first railroad to connect the Mississippi river and Lake Superior, and founder, Treasurer and Director of the Western Land Association, which began the building up of Duluth when the town consisted of but seven houses. He was made President and Director of the National Land Improvement Company. He participated in founding the towns of Colorado Springs and Manitou, and in colonizing the country at the base of Pike's Peak.

Early in his career, while residing in Pittsburg, where he was appointed the first chemical expert for the Pennsylvania Railroad, Dr. Lamborn became acquainted with Mr. Andrew Carnegie and others who have done so much for the development of the industrial resources of western Pennsylvania, with whom he maintained a life-long friendship. Mr. Carnegie writes of him: "As a young man he was thoroughly practical, quiet, reserved, dignified, eminently scientific. . . . He wore kid gloves, which were then rare in western Pennsylvania; this fact rendered him somewhat an object of suspicion at first, something rather effeminate; one had only to know him to see how he survived his kid gloves. Year after year he gained more and more the respect and confidence of all of us, and finally became a friend and one of the circle whose loss was deeply deplored."

Dr. Lamborn, as General Manager of various Western railways, introduced the first coke blast furnaces and the first Bessemer steel ingot and rail works west of the Missouri river.

While engaged in extensive railroad and mining interests, he lost no opportunity of studying the cliff dwellers and other primitive inhabitants, making at the same time collections of pottery and ethnological objects which he presented to various institutions. While in Mexico he devoted much attention to the art of that

country, subsequently publishing his observations in 1891 under the title, *Mexican Paintings and Painters*, Bouton, N. Y. The Lamborn Collection in Memorial Hall, Philadelphia, contains the material secured in Mexico, as well as many specimens gathered in Europe to illustrate the history of civilization in the Italian Peninsula, beginning with relics from the prehistoric Terra Mare period and from the almost prehistoric Etruscan times.

While engaged in building the Lake Superior Railroad, Dr. Lamborn suffered so from the attacks of countless mosquitos, that he became interested in extermination of the insect, and later offered prizes for the three best essays on the subject. These were published under the title *Dragonflies vs. Mosquitos: The Lamborn Prize Essays*, D. Appleton, New York, 1890.

As a beekeeper Dr. Lamborn will long be remembered by many friends who had received from him colonies of Italian bees. He enjoyed the careful study of the social organization of a hive, his special interest being the development of a stingless bee. While intent upon these investigations his identity as a railroad magnate would be quite lost under his bee hat and veil.

While the name of Robert H. Lamborn will not be found recorded among those of the great scientists of the world, his environments, the natural bent of his mind, his broad views of life, together with an executive and business ability far beyond the average, constituted a unique personality. His interests in mining and metals and the demands of business made him a constant traveler over large areas. It was thus impossible for him to give the sustained attention necessary to effectively cultivate the many subjects of natural history which he loved, and in which he might have become eminent if his interests had been more concentrated.

Philadelphia was his favorite city. During the last years of his life he retained here a domicile, and would probably have made his home here had his life been prolonged.

Dr. Lamborn expressed his opinions of the unequal distribution of wealth in a manner which showed his altruistic notions as to the power and influence of money when used productively. He believed that great fortunes should be regarded as capital in trust for the permanent benefit of society, and that the owner of a large amount of money could erect no better monument to himself, than by systematically employing a great number of persons with the

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aim of improving their social conditions. He was opposed to indiscriminate charity, regarding it as one of the causes of pauperism and the natural demoralization which is the usual result of receiving something for nothing.

That Dr. Lamborn recognized the institutions which foster the various branches of science as fitting beneficiaries of his wealth was evidenced by the placing of his collections of archaeological books, ethnological objects, Etruscan relics, Mexican pottery, etc., where, free to the public, they may be used for reference and instruction as additions to the educational resources of the several repositories. He advocated the opening of all museums, parks, art galleries and places of healthful recreation to the public on Sunday, that all might be brought in contact with the beautiful in nature and with man's best handiwork. He placed none of his collections in any museum which exacted an admission fee.

Although Dr. Lamborn was a man of large means, he frequently suggested money-making schemes to young people whom he wished to employ, by offering work on a profit-sharing basis, his object being to engage the earnest attention of students and to develop a love of research, ends more likely to be secured by copartnership than by patronage. As an incentive to study, he frequently offered prizes of money for the investigation of various scientific questions, his interest being especially in the direction of the cultivation of bees and flowers.

Shortly before his death Dr. Lamborn placed a sum of money with the President of Swarthmore College to be paid in prizes for the two clearest and most useful essays upon the theme, "What important inventions, discoveries, observations, ideas or acts tending to advance civilization have been contributed by members of the Society of Friends, or by persons descended from members of that Society, or by persons guided or employed by such members, with an estimate of the number of members composing the Society each twenty years since its foundation." Some essays were written in response but have not been published.

During the greater part of his active life Dr. Lamborn was conscious of the existence of organic cardiac weakness, which, it is believed, deterred him from marrying, and resulted in his sudden death in New York, after a slight, apparently trivial, indisposition, January 14, 1895.

Dr. Lamborn's success in life was due to his persistent efforts to master difficulties, the possession of the loftiest aims and an invincible purpose of acting for the right.

All knowledge which he acquired by personal research or through his patronage of students he cheerfully gave to the world. Science has been enriched by his benefactions to the several institutions in which his library and collections have been placed.

His special interest in the Academy of Natural Sciences of Philadelphia, his devotion to its objects and his approval of its administration have been most practically indicated by the terms of his last will which left to the Society without conditions his entire estate for the advancement of its work in biology and anthropology. Although, because of a legal technicality—a question of domicile and a provision of New York law which seems to have been framed solely for the benefit of lawyers—his benevolent intention has not been entirely fulfilled, the portion of his estate of which the Academy has become possessed by an agreement with the heirs-at-law, forms a most important addition to its resources and will enable the Society to effect such development in the departments indicated as will constitute a lasting memorial of its generous benefactor, who, by the magnitude of his gift, stands first among the many earnest men devoted to the advancement of knowledge who have substantially manifested their interest in its well-being.

Miss Anna Wharton, in the following ode, has briefly given expression to the feelings of many who hold Dr. Lamborn in grateful and appreciative memory:

Esteem he won from many loyal friends,
To whom his well-stored mind and humor keen,
His generous heart, where kindly traits convene,
Had drawn him by that bond which nothing rears.
And now where his remembered image blends
With thronging shadows of the world unseen,
That honored figure of the stately mien
Is crowned with light which grateful memory lends.

His life so full of thought and effort high,
Brought that success which is to sloth unknown,
But as he had not formed that dearer tie
Which makes a home and kindred of one's own,
There at the last no helping hand was nigh,
No love to soothe him, and he died alone.

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Bisq. of Robert H. Lamborn

Introduction.

In this, the century of invention and age of scientific discovery, few more permanent records will be left on the page of history than that which contains the accounts of man's successful efforts to master the insect world and turn the strength or weakness of the various important species to his use.

The vast stores of wealth accumulated by some, lost or squandered or wrested from a helpless community by a seemingly irresistible trust, sink into insignificance when compared with the vast amounts in value which are annually annihilated by the noxious insects of this continent. So great has been

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the recuperative energy of the American people, and so easy has it seemed in the past to prepare crops in sufficiency to allow for a large percentage of destruction, that the annual loss has not appealed to them, as a people, but has simply touched the pocket-book of the individual loser and attracted the attention of the economic entomologist. The great volume of work which has been done and is now in progress in our various State Experiment Stations and on a still larger scale at our National Department of Entomology at Washington, is far beyond the ken of the public, and is even too little appreciated by many entomologists, to some of whom the work of erecting new genera and species is far more fascinating. The records of

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the agencies for relieving man of the dread effects of his insect enemies, which are now estimated at 15,000 species, term with the accounts of successful experiments. The thousands of abortive attempts, which of necessity, were required to lead to final success, are not narrated, and the magnitude of the work which they entailed is thus lost sight of. In the United States, so free are we from a parental form of government, national aid is by no means a necessity, nor is it a prime factor in a large proportion of the results coming from these lines of inquiry.

The public-spiritedness of private individuals has been productive of much which is now recorded of the life histories of noxious insects. It is to this class of incentives to

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economic research, that this essay and others with which it will compete is to be attributed. Much has been written, far more has been said in scientific gatherings of the mosquito and fly as destroyers of human comfort, but the question of their utility is still unsettled, and it is to the generosity of Dr. Robert H. Lamborn that the present discussion is due. If anything of value be added to our present knowledge of these pests, the honor and credit should be his. The circular note issued by him on the 15th of last July, has brought about much beneficial discussion which must lead to a clearer understanding of the problem. We propose to discuss

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this subject in the following order:

- 1.- Life Histories and Structure
- 2.- The Medical Problem.
- 3.- Possibilities and Cost.
- 4.- A Bibliography.

As much that follows may be made more comprehensible by figures of the creatures or articles under discussion such have been added, made from original studies of the natural object, during the past four months. Where any of these illustrations are taken from the works of other authors, credit will be given on the leaf facing the plate.

Equally important to a clear understanding of this entire discussion is a

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knowledge of the literature on the subject.

A bibliography of this sort will be found appended to the essay, with the method of its selection fully explained. The system of reference numbers used is probably the most convenient attainable.

A full reference in parenthesis each time an authority is quoted is cumbersome, and foot-notes are more or less distracting to the attention; consequently, the bibliographical list has been arranged alphabetically by authors or journals, and chronologically under each heading.

These separate references have been numbered consecutively, and these numbers follow an authority when quoted.

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Life Histories and Structure
of Culex.

The Culicidae for the most part prefer stagnant water for their breeding places; not, it is believed, for any advantages in the food producing effect of such water, but because the enemies most dreaded by them are only capable of prolonged life in fresh or water. They have been observed living in considerable numbers in all stages up to the imago in a puddle of water, eight inches square and one inch deep made by the rain in an iron pulley in a foundry yard. They are also to be observed breeding to overcrowding in the roof holes in boggy cow pastures. But the following occurs

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sionally overflowed and replenished by riv-
ulets in swamps, the stagnant pools form-
ed by ditches without outlets, and the
evenly more numerous murky pools made
by the joining of tufts of grass in marshes,
are the usual breeding places in the
rural districts. In village and urban
localities rain tanks, undrained gutters,
badly paved damp-byways and garden
ditches are the most fruitful places for
recruiting their numbers. These sur-
roundings are selected by the female
with a view to the fact that from
three to four weeks will be required
to perfect the changes from the egg to the
larva; and they must be situated so as

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to move sufficient water from rain or outside overflow to ^{by} establish the evaporation or soaking into the ground. In this selection, the female shows the usual instinct, which is so noticeable in insect economics.

E. A. Butler, "Ent. of Pond." (11), has described the oviposition of Culex so graphically, that no excuse is necessary for inserting it here - "Finding some floating shred of straw, stick, grass or other support, the expectant mother rests her two fore legs on this, allows the next pair gently to touch the water, and crosses the third pair behind, to form a sort of vice in which to hold the eggs as they are deposited. Then a long oval egg is

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edged in the angle formed by the crossed
eggs, with its larger diameter vertical;
another following it is joined on to the side
of the first in a similar position, and so on
till some two or three hundred are fasten-
ed into a sort of raft, or rather life boat,
as the mass is curved upward at each
end. Then the little vessel is abandoned
to the mercy of winds and wavelets, and
so floats about for a few days, benefiting
by sun and air, till the growing em-
bryos, finding their quarters too close,
push open a kind of trap door in the
floor of the egg, and take a dive at
once into a watery home."

Then hatches the larva, and the

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sides of pools and shallow margins; owing to the frequency with which they need to come to the surface for air, and the fact that they are not deepwater feeders, they are not usually found in the depths. Much of their time is spent at the surface with the orifice of the airtube just in contact with the air, (Plate 1. fig. 4). Here they are easily frightened by any stir or motion from above, but pay little attention to any dangers which may menace them from the water.

The approach of other insects or of small fish seems to afford them no uneasiness.

Very little is known of the feeding habits of Culicid larvae; the statement that they are scavengers, feeding on de-

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larvae so long in stagnant water is fre-
quently mentioned in popular works, but there seems
to be little that is conclusive in these state-
ments, and we have been unable by observation
to add anything of value. That they do feed
on minute animals, such as Cyclops, Cypris etc.
we have observed, and that they have destroy-
ed young trout is attested by Westwood (175),
and others.

The external breathing apparatus of
the larva Culicid consists of a straight
tube branching at an obtuse angle near the
anal extremity (Plate 1. fig. 1.); this communi-
cates internally with the tracheal system.

To use this breathing tube, the larva
needs remain at the surface, head

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downward and the orifice in contact with the air. After three or four transformations the 'initial' stage is reached (Plate 1, fig. 2) and here a remarkable change in the appearance takes place. The head, thorax, legs and wings all being folded in one mass, and the abdominal segments being left free for the purpose of navigation, the pupa has a very ^{top} heavy and clumsy appearance, although it is quite as active as the larva, but not capable of feeding.

Butler (11) describes an interesting feature of this period as follows: "The most astonishing change of all is that which takes place in the respiratory system; the entrance to this is now transferred to the opposite end

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of the body, and appears as two small twisted horns projecting from the gigantic head.
x x Therefore it turns a summersault in the water, and henceforth goes about head uppermost." (Plate, 1 fig. 3). This change takes place at the surface of the water within two hours.

Authorities vary in their statements of the time passed in the pupal state, but our observations on C. damnosus, the commonest species in this locality, show that only two days are needed in favorable weather in August; perhaps a longer period is required in the cooler weather of spring and fall.

As the insect approaches the imago stage it needs more air, and consequently remains altogether at the surface, unless

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disturbed from above, it descends quickly below and rises again almost immediately.

The newly formed pupa is usually much paler than that of a few hours existence, and its bulk also appears to increase slightly. When the period of emergence arrives the abdominal segments are distended backwards on the surface and the pupa cracks through the middle of the cephalothoracic region. Now the imago may be seen to rapidly extricate itself, using its long hind-legs to push with, and balancing itself with the anterior and middle pairs. Though it can stand for ten or fifteen minutes on the surface free from the skin, the surface must be very smooth, or covered with

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a scum; a high wind is "sure destruction," and even small ripples make the task a hazardous one. After the puparium is abandoned the imago stands lightly on the water holding up first one leg, and then another, evidently drying the feet; suddenly it takes wing and disappears. This is the method in an open

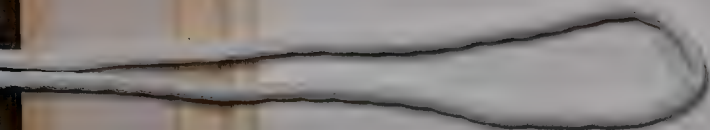
pond or a tank; where grass or other growth abounds along the margins, it is usual for the imago to emerge in such a position as to crawl directly up on some stalk, and proceed more rapidly. We have seen C. damnosus fly away in four and a half minutes from the time of emergence when there was no herbage to facilitate

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the proceeding. From this time forth the
principal objects in the remaining ex-
istence are the search for the desired mate
and the duties of reproduction. To sup-
pose that the tormenting of man occu-
pies any considerable time in the mosquito
economy is certainly a mistake. It is
only the female (Plate I fig 5) which can
thus make our lives miserable. In repeat-
ed examinations of hundreds of individual
specimens, we have failed to find a single
male with a distended abdomen contain-
ing human blood, and subsequent microscopical
study has shown the male proboscis inca-
pable of drawing blood. Dr. Bonaria (8)
has a readable article entitled "Do Mosquitos

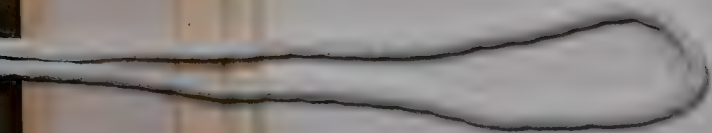
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live on Animal or Vegetable juice?" relates
the following: "On one occasion I, in a plant
in a pot in my room. At night I happened
to pass by it, with a lamp, and found its
leaves covered with mosquitos, who appear-
ed to me to be sucking the juice of the
plant. Here is then the clue I had discovered
a clue to the real nature of the mosquito.
I think that naturally the perfect insect
lives by sucking the juices of plants
at night *** With the foregoing clues
I think now the statements of travelers
and sportsmen in the jungles of Burmah
and of trappers in the backwoods of
America and Canada become intelligible."

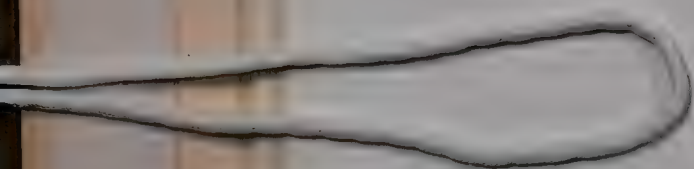
Dr. Dimmock (24) has by keeping a

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male mosquito, several days, had the satisfaction of seeing it drink freely from a moist cloth. We have observed a male to alight several times on a hand held perfectly motionless, and after searching for some unfound dislodgement, to fly to a water, pitcher and dip its proboscis in a drop on the rim. We have also noticed a female on a molasses sug. imbibe freely. These habits, and others too numerous to here detail, as well as the fact that miriads of these insects are born in such localities as ever to enable them to find human victims, seem to show that bloodsucking is a natural taste to the female alone; and even here it is a secondary

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consideration, a means to an end—the first
of sustenance needed until the re-
laxative period is passed and her brief
life is finished.

The irritating effect of the mosquito
bite has long been a source of much con-
flicting testimony. Especially in the pop-
ular prints has the "Sting of a Gnat" figured
as a formidable weapon, and at times has
it assumed the proportions of a veritable
hyperdermic syringe, loaded with the most
virulent poison. From Westwood's *Classi-*
fication (—) we extract the following;
"It is supposed that at the same time it
institils into the wound a venomous liq-
uid, which, while it enables the blood to

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flow faster, is the chief cause of the trouble."

Packard (114), after quoting the above says:
"So far as we are aware, no poison glands have
been demonstrated to exist in the head of
flies, or other six-footed insects, and we are
disposed to doubt whether any poison is
poured into the wound, and to question
whether the barbed mandibles are not
sufficient to produce the irritation ordi-
narily accompanying the punctured wound."

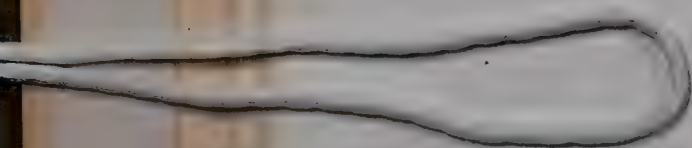
Two Biologists of our own country, have con-
tributed much of our present knowledge of
the sucking apparatus on Quercus. Dr. Geo.
Mimmo (24) of Cambridge, and Prof.
Wacloskie, of Princeton (88) have each
given the Entomological world, the bene-

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fit of patient research and study in this
department of Dipterology. To the latter
is alone the credit of discovering the ex-
istence and probable nature of certain
canals in the antero-inferior region of the
thorax of Culex, which evidently com-
municate through a duct which in turn empties
into the reservoir at the base of the hypo-
pharynx. Says Prof Macloskie: "The
secret was first discovered by an observa-
tion of fine droplets of a yellow, oily-look-
ing fluid escaping from the apex of the
hypopharynx." This seems to settle the
question suggested by Dr. Dimmock (24)
when he says that he believes "without as
yet being able to give anatomical proof of it,"

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that the buccal larynx of Culex contains a duct that pours out its "poisonous saliva."

We have collected several of the figures of these animals as illustrate the dissections made; notes of explanation on the page facing, in which no further notice is necessary.

It has been demonstrated in many instances that if the female be allowed to feed undisturbed, and allowed to fly away undisturbed, the effect of the poison is very much reduced; in some cases entirely so. It is the interrupted performance which produces the greatest itching. This seems to prove that if allowed to finish her meal undisturbed, the mosquito will pump back the venemodulatory secretion, whereas a quick withdrawal of

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the tick results in the consequent abandonment
of this irritating fluid to be a source of an-
noyance to the flesh.

There are certain diseases, however,
in which it is used as a means for their extirpation; it
is their overhauling number which constituted
the chief terror. Aside from their rapidly suc-
ceeding broods, their nonmigratory, and hibern-
ating tendencies are especially calculated to
keep up the enormous numbers, which Na-
ture seems to regard as their full quota.

Commenting on the latter, *Pestwood* (173)
and *Young* (180) call attention to the fact that
various species of the mosquito tribe hibernate
in houses. Our own experiments in raising

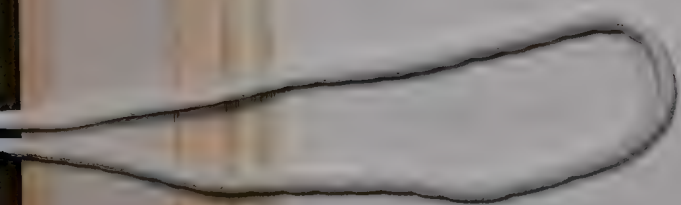
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many thousand of these insects have resulted
the presence at this writing, of a large num-
ber of three species of Culex in our cities.

The migration of mosquitos has been
the source of much misapprehension on the
part of the public. The idea prevalent at
our seaside resorts that a land breeze
drags the swarms of mosquitos from far in-
land is based on the supposition that it
is capable of long sustained flight and a
certain amount of battling against the
wind; this is an error; mosquitos are frail
of wing, a slight puff of breath will illus-
trate this, by "hurling" the helpless creature
away and it will not venture on the wing
again for some time. It is therefore safe

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harbor. The prevalence of mosquitos during a land breeze is well explained. It is usual only during the lulls in the wind at such times that Culex can fly. Generally on our coast, a seabreeze means a stiff breeze, and during these even the Odonata, and often the robust and venturesome Tabanidae, will be found hovering on the leeward side of houses, sand dunes and thick foliage. In the meadows south of Atlantic City, N. J. large swarms of Culex are sheltered in the dense grass or wind-battered tree tops on the offside of the sand dunes. Here in common with all localities so exposed to searching wind, the trees and large bushes are much stunted in growth and battered down to a flat

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top and common level by the wind. In these
matted branches, dense with the close cluster
of leaves, the mosquitos may be discovered in
great numbers as to bring death to the breast
of the student who is plotting their final
extermination. While the strong breezes last
whether from land or sea - Culex will stick
close to these friendly shelters, though a
cluster of houses may be but a few rods
off, filled with unsuspecting mortals who
imagine their tormentors are far inland over
the salt meadows. But if the wind dies
down, as it usually does when veering, out
come swarm upon swarm of the females in-
tent upon satisfying their depraved taste
for blood. This explains why they appear

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on the field of action almost immediately after the cessation in the strong breeze; on the supposition that they were blown far inland this sudden reappearance would be unaccountable.

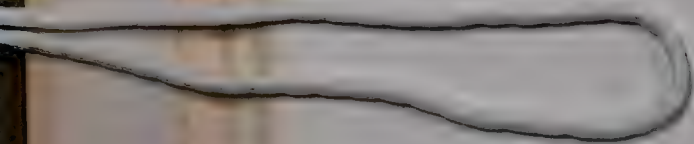
So local are the ranges of the Culicidae, that every observer has noted that they may be seen year after year, flying in tall columns, and breeding swarms in exactly the same localities as the year previous. "E. L. A." (2) describes these swarms as "so vast that they looked like the ascending smoke of a campfire, and so numerous that the hum of their myriad tiny wings could be heard at least thirty yards." Nagis (85) also writes of this habit.

Unfortunately for us, these flights occur at an hour when we were the most uninteresting

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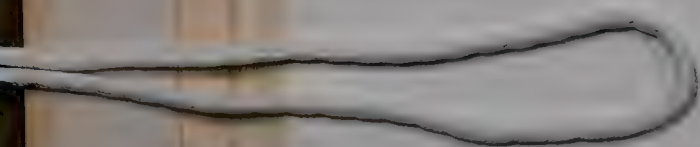
Odonat has betaken himself to his night's rest, and only the swallow or whip-poor-will is likely to make any effective attack on these insects. This must be remembered when we come to a final discussion of the Dragon fly as a Mosquito destroyer; their times and habits of flight have but little in common; not only their daily period of flight but the annual period as well must be noted in this connection. One or two broods of mosquitos appear in the middle Atlantic seaboard region after the Odonats have become very rare or have entirely disappeared.

It now remains merely to allude to mosquitos as pests in other ways than as biters and our treatment of their life history is

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hundred or more species of Simulium. Their
poisonous character will be discussed in our
paper on the medical aspect of this subject.
They may be found everywhere with
the wild and manufactures by their great
numbers, (H. Clarke (16) and others have mar-
shaled. Perhaps the most surprising charge
made against them is that of Murray (101),
who states that he has observed the imago
of Culex light upon baby trout which
come to the surface of the water and liter-
ally blow out their unsuspecting little
lives before they could escape.

So considering the above, we have been
able to observe the poison droplets, alluded

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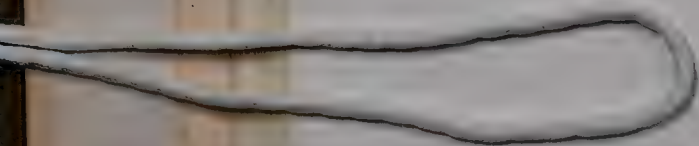


to by Macloskie (83), see page 21, and have
... successful in getting this minute a
mount of fluid on the point of a needle.
An attempt to inoculate ourselves with
the poison was however not successful,
owing probably to the inferiority of the
needle as an injector, compared with the
delicate hypopharynx.

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Life Histories and Structure of Musca and Allies.

It is not our purpose to devote as much space to the early stages and habits of Musca and its allies as has been given to Culex, for the following reasons: 1st They are better understood and the descriptions in the various textbooks of the Science are fuller and more accurate in detail.

2nd— In the larval or maggot stage they are undoubtedly as a family, not open to the attacks of the Odonata, and consequently, only such habits of life which place them in the enemies' reach, need be discussed.

3rd— In the imago state the most casual observer has a fair opportunity to judge

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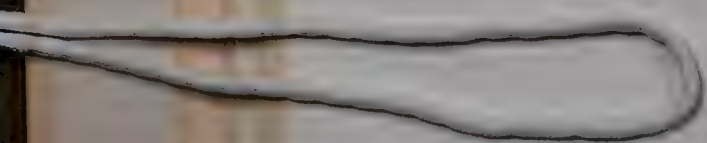
for himself just how far the house-fly is liable to attack from insect enemies; such liability can be left to another chapter for discussion.

As an introduction to our consideration of these insects it is well to premise our account by the statement that we will take Musca domestica as the type of its group and all that hereafter follows will apply to that species, unless it is otherwise stated.

M. domestica of this country is undoubtedly by the same insect as the domestica of Europe, its identity and introduction to this country having furnished the systematists much food for interesting discussion in the past.

One peculiar item of its systematic position is that the name is misleading; Prof. Snodgrass (52)

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V. 10



has pointed out that domestica is the first visitor at any camp in our back woods in North America, no matter how remote from civilization; and in using the sweeping net for minute insects, in grass, shrubs, or trees, we find domestica well represented; and it can as well be called the commonest insect away from domestic surroundings as in our houses.

Packard (108) has given us a full description of the oviposition of Musca. The principal facts gleaned from which are as follows: Fresh horse manure with plenty of heat and moisture furnishes the best food for the young maggot. "From a hundred to a hundred and fifty eggs are deposited in irregular, loose stacks,

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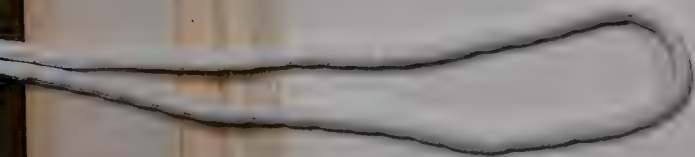


usually within eighteen hours, and hatching
in twentyfour hours or less. The maggot
moult twice; the three stages of larval de-
velopment being of the following periods:
1st stage, one day; 2nd stage from twentyfour to
thirty six hours; 3rd stage, three or four days.
To this maximum period of seven days is
to be added the same length of time for
the pupal life: thus it will be seen that
fifteen or sixteen days are required for the
entire development from egg to imago.

These stages are illustrated in plates 3, figs. 8 & 9.

The rapid changes following so rapidly
in generation after generation make it im-
possible for the student to separate broods,
and it is therefore easy to account for the

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A. 7
V. 1



immense numbers of houseflies which are everywhere and always present. Even in years when flies are, by comparison with former seasons, said to be scarce, they are still present in sufficient numbers to be safely considered the most plentiful insect in America. Barrington (52) in a readable, popular account quotes Linnæ to the effect that three flesh flies "with their progeny could eat up a dead horse as quickly as a lion could." This truth, impossible as it seems at first, coming as it does from the great naturalist, explains why, when the season favors and its natural enemies are greatly abated in numbers, these insects—the whole tribe of Muscine—are to be found in swarms defying

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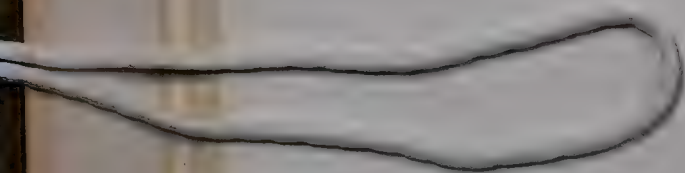
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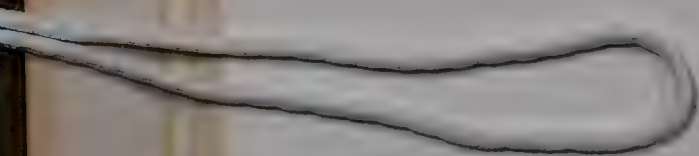


computation. J. A. Stewart (187) speaks of a "plague of flies" in Ireland, in 1878, so extensive that stones and plants for about one and a half miles along the Bann were completely covered with the pupae cases from which they issued in millions, and attacked both men and cattle." In a few days the ground was strewn with the dead flies, in some places lying three inches deep. J. H. Smith (148) writes of a column of flies, thought to be Ab. domestica, issuing from a crack in the wall of the palace at Delhi, India. In a band about seven inches wide they marched out of the shadow of the building, and as soon as their wings dried in the warm sunlight, took flight. They could not be made to

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as a complicated instrument as a live animal."

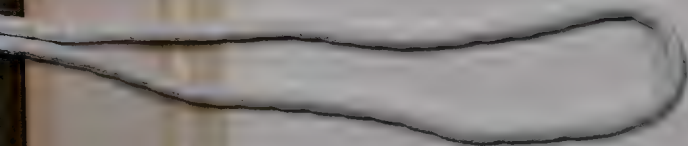
The popular and semiscientific journals abound with accounts like the above, and many references could be made, but these will suffice. When we come to that phase of its life history in which the testimony for or against the unobstructed existence of M. domestica is to be gleaned, we find that comparatively little has yet been discovered. In our chapter on the Medical and Economic character of the subject, a full discussion will be found.

"Doubtless the great majority of people," says Harrington (52), "would affirm that the house fly is in the habit of biting persons. But from the formation of the fly's proboscis

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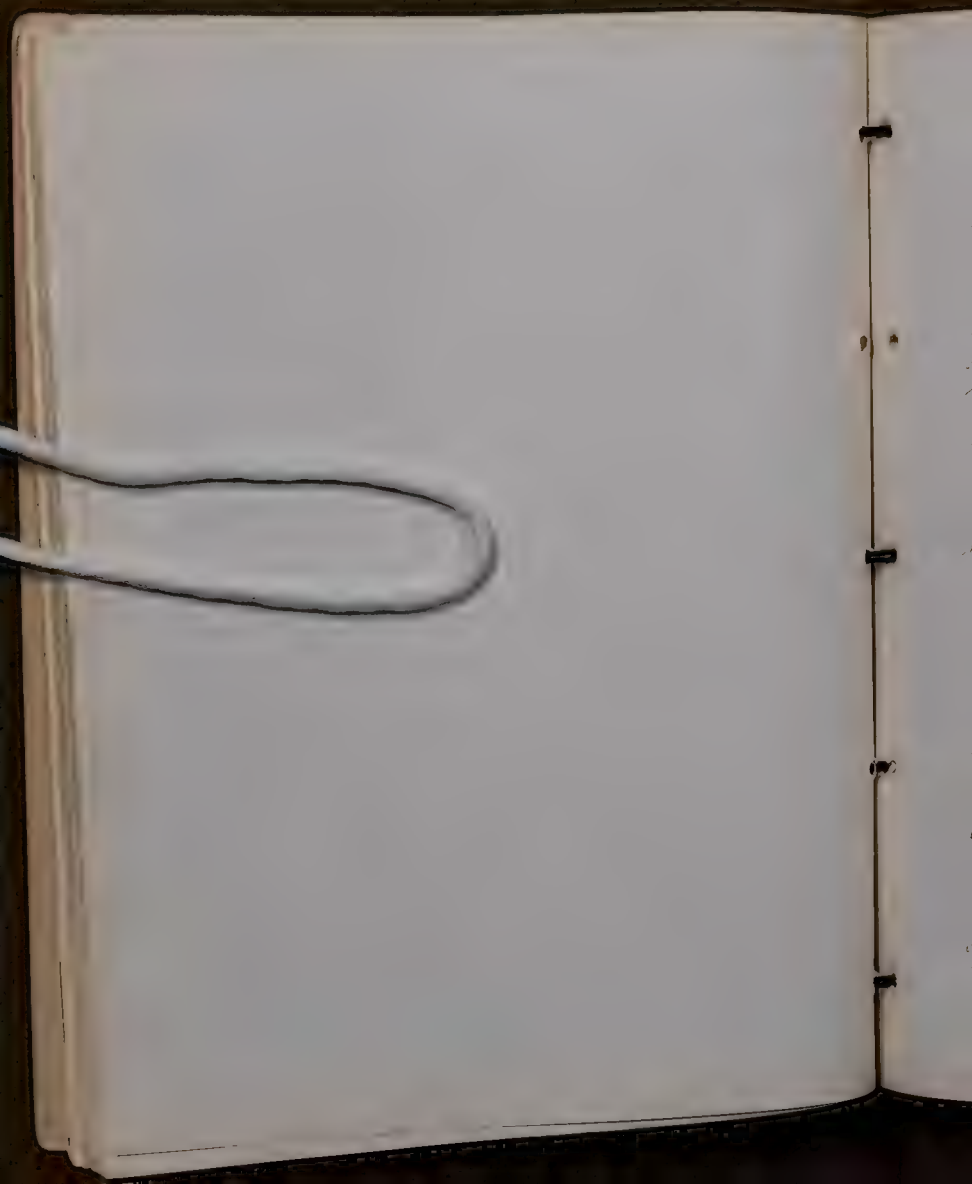
Note 3 fig 4.6. gives an idea of the

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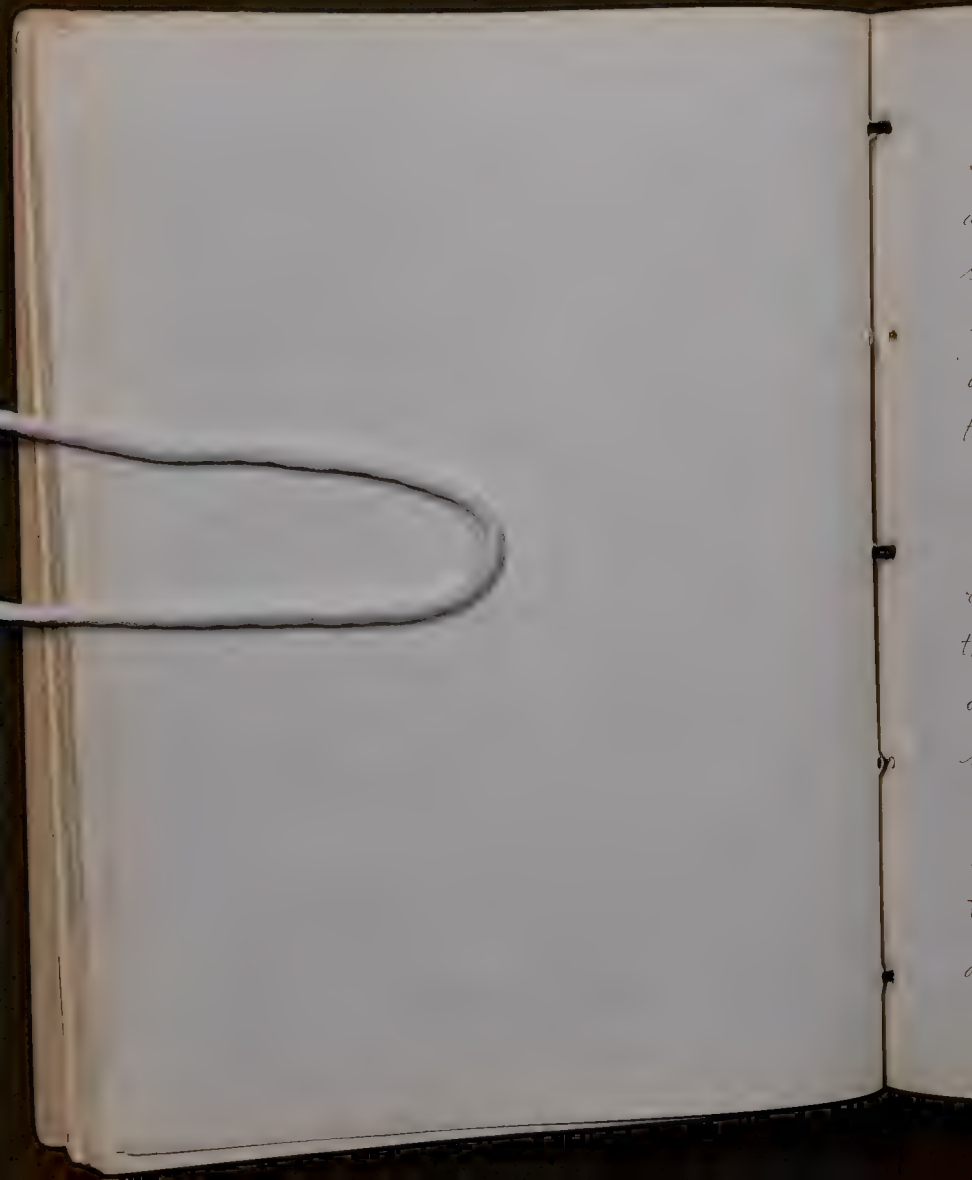
the senses between this so age and others and the more numerous and id. . Cusca. In describing the wonderful adaptability of the mouth parts, Packard (Quadr. 6409) says "In the proboscis of the house fly, the hard parts are obsolete, and instead we have a ¹ ² ³ ⁴ ⁵ ⁶ ⁷ ⁸ ⁹ ¹⁰ ¹¹ ¹² ¹³ ¹⁴ ¹⁵ ¹⁶ ¹⁷ ¹⁸ ¹⁹ ²⁰ ²¹ ²² ²³ ²⁴ ²⁵ ²⁶ ²⁷ ²⁸ ²⁹ ³⁰ ³¹ ³² ³³ ³⁴ ³⁵ ³⁶ ³⁷ ³⁸ ³⁹ ⁴⁰ ⁴¹ ⁴² ⁴³ ⁴⁴ ⁴⁵ ⁴⁶ ⁴⁷ ⁴⁸ ⁴⁹ ⁵⁰ ⁵¹ ⁵² ⁵³ ⁵⁴ ⁵⁵ ⁵⁶ ⁵⁷ ⁵⁸ ⁵⁹ ⁶⁰ ⁶¹ ⁶² ⁶³ ⁶⁴ ⁶⁵ ⁶⁶ ⁶⁷ ⁶⁸ ⁶⁹ ⁷⁰ ⁷¹ ⁷² ⁷³ ⁷⁴ ⁷⁵ ⁷⁶ ⁷⁷ ⁷⁸ ⁷⁹ ⁸⁰ ⁸¹ ⁸² ⁸³ ⁸⁴ ⁸⁵ ⁸⁶ ⁸⁷ ⁸⁸ ⁸⁹ ⁹⁰ ⁹¹ ⁹² ⁹³ ⁹⁴ ⁹⁵ ⁹⁶ ⁹⁷ ⁹⁸ ⁹⁹ ¹⁰⁰ ¹⁰¹ ¹⁰² ¹⁰³ ¹⁰⁴ ¹⁰⁵ ¹⁰⁶ ¹⁰⁷ ¹⁰⁸ ¹⁰⁹ ¹¹⁰ ¹¹¹ ¹¹² ¹¹³ ¹¹⁴ ¹¹⁵ ¹¹⁶ ¹¹⁷ ¹¹⁸ ¹¹⁹ ¹²⁰ ¹²¹ ¹²² ¹²³ ¹²⁴ ¹²⁵ ¹²⁶ ¹²⁷ ¹²⁸ ¹²⁹ ¹³⁰ ¹³¹ ¹³² ¹³³ ¹³⁴ ¹³⁵ ¹³⁶ ¹³⁷ ¹³⁸ ¹³⁹ ¹⁴⁰ ¹⁴¹ ¹⁴² ¹⁴³ ¹⁴⁴ ¹⁴⁵ ¹⁴⁶ ¹⁴⁷ ¹⁴⁸ ¹⁴⁹ ¹⁵⁰ ¹⁵¹ ¹⁵² ¹⁵³ ¹⁵⁴ ¹⁵⁵ ¹⁵⁶ ¹⁵⁷ ¹⁵⁸ ¹⁵⁹ ¹⁶⁰ ¹⁶¹ ¹⁶² ¹⁶³ ¹⁶⁴ ¹⁶⁵ ¹⁶⁶ ¹⁶⁷ ¹⁶⁸ ¹⁶⁹ ¹⁷⁰ ¹⁷¹ ¹⁷² ¹⁷³ ¹⁷⁴ ¹⁷⁵ ¹⁷⁶ ¹⁷⁷ ¹⁷⁸ ¹⁷⁹ ¹⁸⁰ ¹⁸¹ ¹⁸² ¹⁸³ ¹⁸⁴ ¹⁸⁵ ¹⁸⁶ ¹⁸⁷ ¹⁸⁸ ¹⁸⁹ ¹⁹⁰ ¹⁹¹ ¹⁹² ¹⁹³ ¹⁹⁴ ¹⁹⁵ ¹⁹⁶ ¹⁹⁷ ¹⁹⁸ ¹⁹⁹ ²⁰⁰ ²⁰¹ ²⁰² ²⁰³ ²⁰⁴ ²⁰⁵ ²⁰⁶ ²⁰⁷ ²⁰⁸ ²⁰⁹ ²¹⁰ ²¹¹ ²¹² ²¹³ ²¹⁴ ²¹⁵ ²¹⁶ ²¹⁷ ²¹⁸ ²¹⁹ ²²⁰ ²²¹ ²²² ²²³ ²²⁴ ²²⁵ ²²⁶ ²²⁷ ²²⁸ ²²⁹ ²³⁰ ²³¹ ²³² ²³³ 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tongue, extends it, and the broad-knoblike
end divides into two flat, muscular leaves
which form a broad surface, with which the insect
succeeds in scraping or tearing delicate surfaces.
The inside of this broad fleshy
extension is rough like a rasp, and as
superior plates is easily employed by the
insect in scraping or tearing delicate surfaces.

The foregoing graphic description of
this organ, the accuracy of which we have
carefully verified by minute examina-
tion seems to demonstrate that the house-
fly is not a biter.

Alluding to its *raison d'être*, a sub-
ject which fittingly closes this chapter
the same author (111, p. 479) writes "It



should be remembered that flies from an infancy as maggots, and the loathsome life they lead as scavengers cleanses and purifies the August air, and lowers the death-rate of our cities and towns. Thus the young of the housefly, the flesh and the blowfly with their thousand allies are doing something towards purifying the pestilential air and averting the summer brood of cholera, diphtheria and typhoid fevers which descend like harpies upon the towns and cities.

This useful species, to which man owes more than he can readily estimate, and with which he can dispense only when the health of our cities and



to... is looked after with greater vigilance and intelligence than as perhaps seems to be the case for several centuries to come."

As belonging less to life history and more to the domain of the medical question, we omit from this portion of the essay all mention of such species of Diptera as Cestrus, Anthomyia, et al. which are known to be inimical to the health and comfort of man by reason of the hyphodermic or intestinal habits of their larvae.

Several continental writers believe that the oily papillae which enable flies to adhere to smooth surfaces, are the means of transporting disease. The fly's foot is illustrated. pl. 2 fig. 4.



Life Histories and Structure
of the Odonata.

In approaching the life-histories of the Odonata, we find ourselves confronted with a more complicated series of events, and a far more difficult problem to solve.

While the preparatory stages approximate those of the Culicidae, the imago on the other hand, are possessed of habits, which on account of their powerful flight and wary nature, are extremely hard to observe.

Much which is now known is the result of chance observation, and the patient research of several seasons is needed to throw light on the subject now under our consid-



nation. In their habits of flight the Odonata may be divided into three groups, and these are nearly classificatory in value, though not absolutely so. The first group, comprising such genera as Agrius, Lestes, Calopteryx, et al. usually known as the "hammer-headed dragon-flies", plate 4, figs 4, 5, frequent the grassy margins of pools and ponds, and the low bushes and shrubbery by swamps. Flying from stalk to stalk, darting after insects, they are typically the hawks of the minuter insect world. The second group with true Aeschna and Cordulia as its principal representative genera, plate 4, fig. 3, are high fliers and mighty knights of the upper air. They are the largest



of their suborder. They haunt the tall sim-
ple, the middle and upper portions of the
trees, seldom come within easy reach of the
collector, and are less frequently seen over
the ponds and water ways. They are pre-
eminently the enemies of all juicy winged
insects which leave the lower levels in their
flight. So rarely an insect is too large
to tempt them to an onslaught, and this
rapacious disposition is often the cause of
many a mid-air conflict between two or
more of their own kind. Their flight is
more sustained than others of the Odonata;
they seem to be absolutely untiring. From
early morn until evening they are constant-
ly on the wing seldom resting save to drink.



their prey, and not always strictly
at. On account of their later hours it
would seem that this branch of the family
are best suited to a nocturnal life
near the coast of fishing, &c. &c.

The second group, with the genera Cer-
thia, Uria, of the Chloropoda, and Cer-
dusia, Tamias, Phalaropus, Quadrupes, &c.
the Chloropoda is as the most diversified
in its habits & its range, but in
one and individuals it is more or less
are more or less on the water as Chlor-
opoda but not on the land as Cer-
and lofty birds. Tamias, Phalaropus
of them safely in sea, but the Chloropoda
they do not leave their den, and are as

* see plate 4, figs. 12, & 6.

† see plate 5, fig 4.



as a rule in the "insect world" In their methods of oviposition there is but little latitude for variation.

Uhler, (Packard, 114) has observed Libellula
Auripennis drop a bunch of eggs while
balancing herself just above the surface of
the water, and the same insect he has seen
settled upon the reeds in brackish water
with her abdomen submerged and there
attach a cluster of eggs. Others of the same
genus fly at the water with a dash, striking
the end of the abdomen, and deposit eggs
on the surface. Todd (162) calling attention
to this habit in a species of Aeschna, sug-
gests that it may serve as a habit to rid
them of parasites. Davis (22), Gunn (28)



Phir (170), Todd (162) and Aaron (1) have noted the habits of various species which go beneath the water for some distance.

Todd has seen a Libelula remain under water for a half hour depositing eggs on a stem. McLachlan (95) has called attention to Agrius mercuriale with a part of the abdomen incrustated with mud caused by sinking its eggs in the mud left from dried up broods.

Packard has observed Perithemis dormitia depositing its eggs on floating refuse on a pond. Lacaze-Duthiers is quoted by Packard (114) as authority for the fact that the Agrius make a little notch in the plant for their eggs. With the exception



tion of this last habit, all that has been
arrived has been verified by our per-
sonal observation.

On the 12th of October, five pairs of Dip-
lar rubicundula, in copuli, were altogether
in a little bay, hardly two feet square,
which ran in from a reedy pool, deposit-
ing eggs so earnestly, that the observer
was allowed to approach very close. Two
downward strokes of the abdomen seemed
to be necessary to deposit the egg which
floated for an instant, although some
went at once to the bottom. We are of
the opinion, based on personal observation,
that this habit of ovipositing in copuli,
very materially aids the female in flight



and thus enables her to elude the ever-watchful frogs which lie in wait at such times. Many a hapless female and her carefully deposited cluster of eggs disappear down the voracious gullet of the frog.

It is evidently with the view of preventing this catastrophe that the female of a species of Aeschna, as related by Morrison (88), has been observed to plaster its eggs with sand or mud at the margin of the pool. For the purposes of study, the eggs of the Odonata are readily obtained; gentle pressure on the abdomen of an egg-laden female will furnish a few.

Owing to the protracted development we have been unable to determine the exact



length of time required for the eggs to hatch.

European entomologists give periods varying from six days to several months, the latter being the case when the winter is passed in this stage. A set of Zepia rubicundula eggs obtained early this fall are yet unhatched and will probably pass the winter so. Packard (114) has described the egg development of Zepia minutely, and we can add nothing to his full details.

Odonat larvae are sluggish and unable to make quick well directed movements of the whole body. The powers of locomotion are very poor when their predatory habits are considered; the legs are feeble and used for crawling



and burrowing in the mud. The larva however possesses a locomotory power which is derived from its ability to suddenly force out the water contained in its abdomen, thereby propelling the body forward for some distance, but this function is not entirely under control, the larva cannot always strike the desired point. It is here that a most remarkable structure plays an important part. On turning over one of these insects it will be found that the underlip is greatly enlarged and is folded over the mouth parts so as to earn the name of "mask". Plate 5, figs. 3 & 5, show how it is hinged, and the formidable extremity. It seems that "all the mus-



cular organs and sensors of which function
were attached to this organ. Motion can
exceed the rapidity with which the mask
is shot forward and its helpless prey is
seized. Then this arm-like lip is used
as a fork to hold the food which it slow-
ly feeds into the capacious jaws. The
size and structure of this "mask" clear-
ly indicate, in our opinion, that such
hungry victims as Culicid larvæ were
intended as the natural food to
be seized by an appendage, which is ca-
pable of catching and firmly holding
prey quite as large as the insect to which
the mask belongs. Packard (114) regards
the Odonata as scavengers; he says: "In the



water they prey upon young mosquitos
and the larvae of other noxious insects, **
and cleanse the swamps of miasmata."

As stated by the same author, mosquitos
also destroy miasmata, the fact that
Odonats feed upon them would seem
to remove them from the category of
useful scavengers. As a matter of
fact we have been unable to get them
to eat anything in the least decayed.

Their preference is for fresh and living
food. The Italian entomologists recommend
pieces of fresh fish for feeding Odonata
in captivity, but urge that they be substituted
with fresh sweet food. Pis (7) states
that nearly 50,000 young fish were des-



trophy by a species of Libellulidae, in a
pool in "Huncheon". Riley and Howard
(134) mention a case, on the authority of "H.
H. Jones, of Atlanta, Ga.", where the larvae
of Anax junius were found feeding on
young catfish. In our several aquaria,
we have studied the appetites of our lar-
vae under various circumstances, and
have been led to state that even with
thousands of Culex larvae provided for
them, the young Odonats will exhaust every
other source of food first, and then attack
each other. This latter habit is a serious
one when artificial propagation is to be
considered. Coulton (120) thinks that can-
ibalism among larvae frequently arises

from scarcity of food, but our is our
adequate portion & all are ca-
pable of living.

Species of Agabus, Cic-j-j-ria and a
few genera, and Notonecta Mudulata fur-
nish the young dragonfly with dainty
food and while there remain any of
these, the Culex larvæ are unmolested.

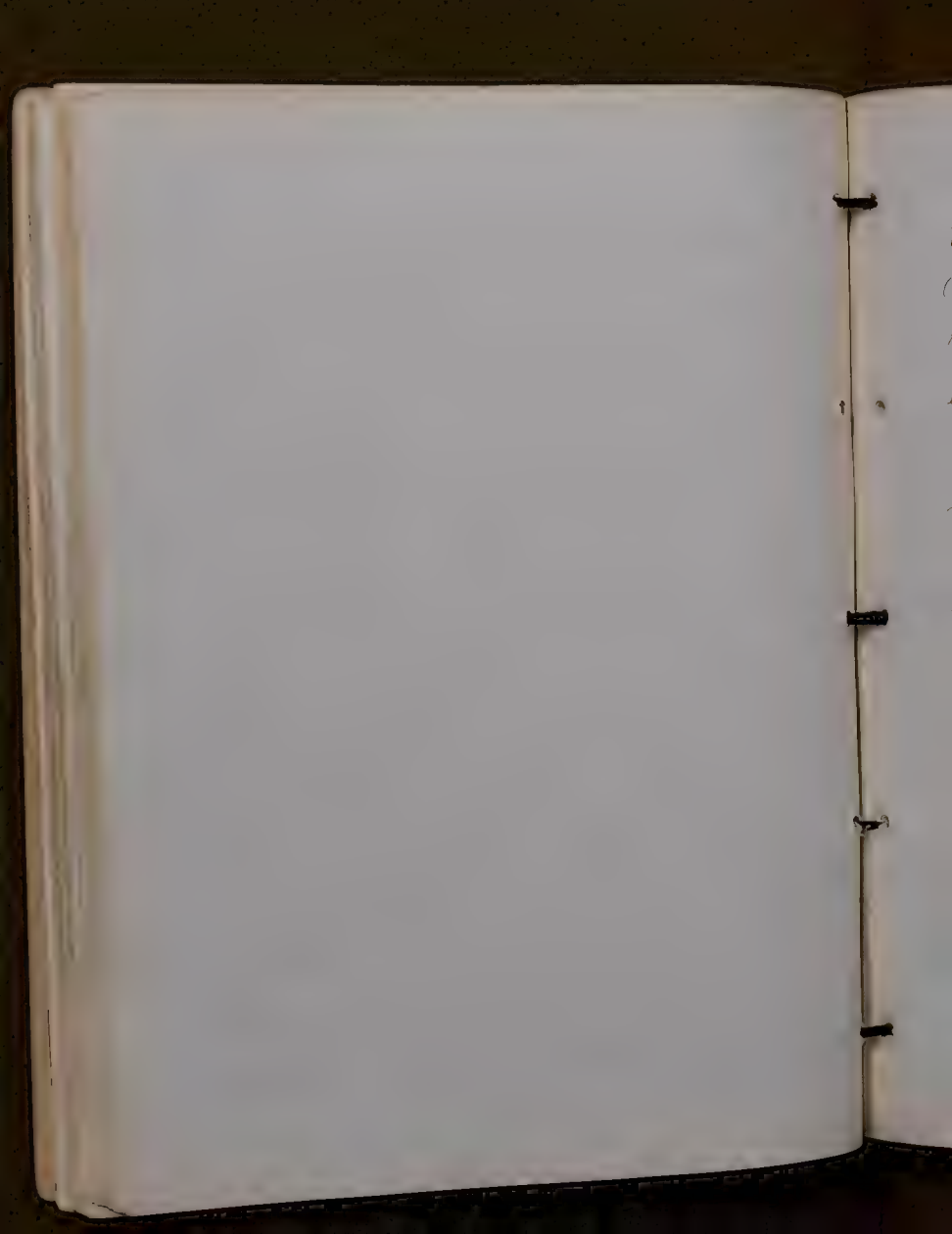
The slender soft-bodied "wigglers" usually
succeed in eluding the rather ponderous
apparatus evidently intended for larger,
hard-bodied game.

As the Odonat grows toward ma-
turity (pl. 5 fig. 2) its form becomes more grace-
ful and its movements less clumsy, but it
is still sluggish and prefers to remain



at the muddy bottom. Butler (11) thus describes this habit: "When you have brought yourself to perform the disagreeable task of hauling out of a dirty pond a mass of slimy weeds and fetid mud, and have deposited it on the bank, you see the mass here and there heaving with the struggles of these ugly brutes as they work their way into daylight and drag their grimy bodies out of the treacherous and unsavory nest. What a contrast between this sordid life and the gay and brilliant existence of the shiny-winged adult."

How these creatures breathe is almost a mystery. Hagen (48) has described the wonderful apparatus which enables them



to reside under any circumstances. Coates
(112), and Packard (107) also give details of
the same, but are so full of contradictions
as to refer the reader to those authorities.

The duration of the stages from the
egg to the imago has not been determined.
Enough is known, however, to lead us to
believe that very few species of *A. g.* are two-
brooded. Most of the species are known to
live in the imago state a long while,
and reproduction is carried on for a number
of days by the same individual. Larvae
of the same brood develop unequally, some
far outstripping their fellows in rapid
growth and utilizing their tardy compan-
ions as the principal articles in their bills.

of fare. From noon to 10. months is ac-
quired to her, it is a dreary, un-
winged existence is enjoyed but for a few
weeks at most.

When the time for the imago to emerge
arrives, the pupa climbs out of the water
on some stalk or dry place, the back
curves and the perfect insect, a knight in
mail, a veritable prince of the insect realm
emerges, ready to "tilt against the field."

Now our Odonats have reached the
period in their tedious and varied ex-
istence when if ever, they are to do the
most effective work in thinning the
Culicid ranks. Enough has been
written of the hours and habits of flight

The season of their usefulness is for the most part restricted to the warm weather.

They become rarer about the time that mosquitoes are the most obnoxious.

In the matter of flight, they are very local seldom ranging from their accustomed haunts save in case of migration.

So we find it impossible to conceive that they could ever be brought to frequent dark woods or other sheltered places where there are no insects that are incessantly breeding, as is the case with Culex.

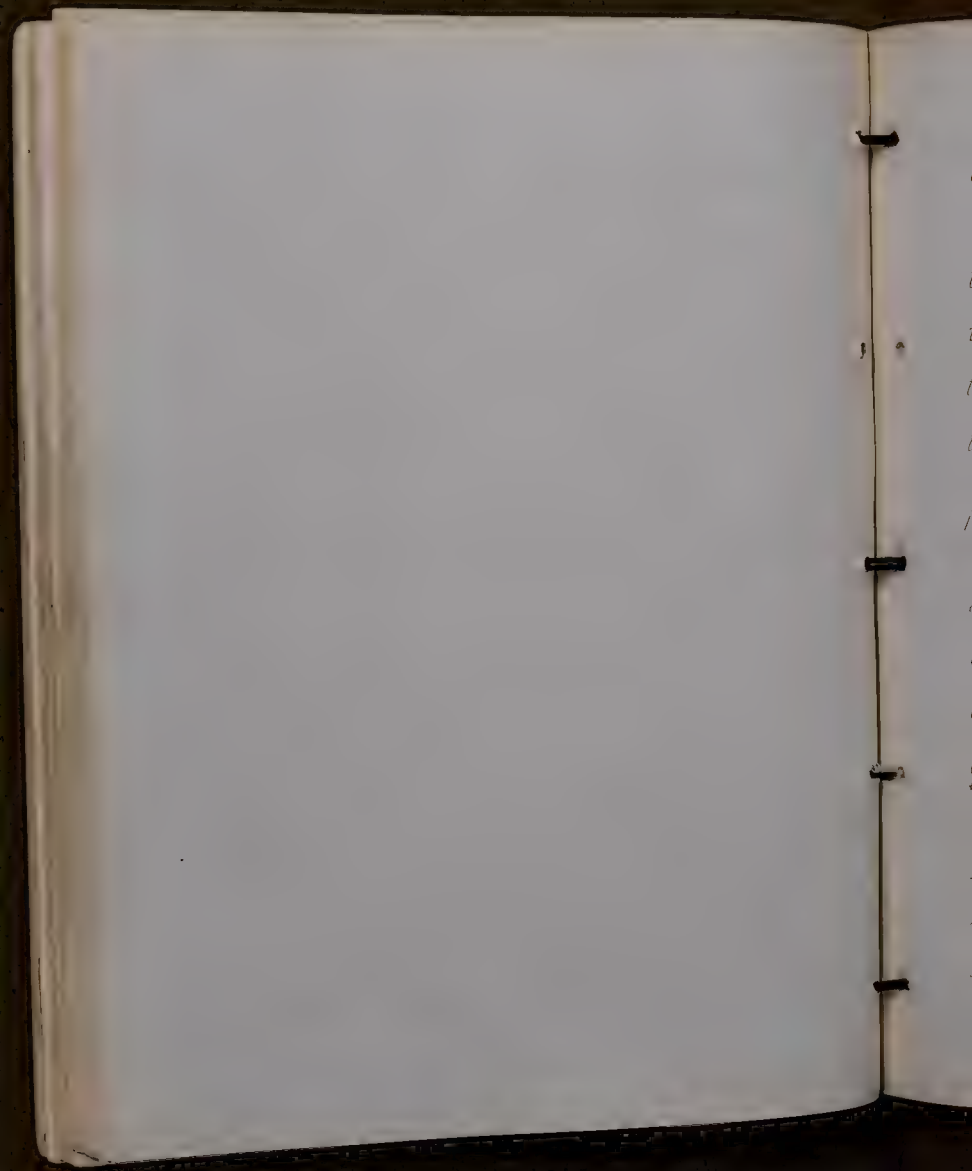
As their enemies among the Odonata are very difficult to name. Our experience and observations lead us to believe that they prefer robust meaty insects, such as

grasshoppers and bugs. The study of their food preferences in confinement is most misleading. So rapacious are they, so fierce in disposition and so well adapted for any kind of chewing, that they will eat anything which is forced upon them. In one case an *Anax junius* devoured with evident relish seven of its own abdominal segments, which were severed from the rest of its body.

The habit of migration among dragon flies will militate against their efficiency as mosquito destroyers. This peculiarity has drawn the attention of Entomologists for many years past. Newton (62), Van Dassel (66), Kuwert (63) Van Bemmelen (65)

and Ghysser (15) have all noted extensive migrations in Sweden, Denmark, The Hague, Rotterdam and Copenhagen; in one instance lasting four days. Mathew (90) Staudé (143) and Froment (40) have observed migrating swarms at sea, far from land. Torrey (63) gives an account of a flight at Hingham, Mass. extending a quarter of a mile wide and lasting from 8 am. until it was too dark to see them. A close observer watched a flight at Cape May this season and adds very pertinently "the mosquitoes were as plentiful at the time and afterwards."

South eastern Texas and East Louisiana are localities where migrating Odonats



are no uncommon spectacle.

Several of the above writers have attributed this most interesting habit to the fact that the ponds drying up in the neighborhood caused them to abandon their haunts in self defence. Such an explanation must surely fail near the sea board where many of these swarms occurred. Be the cause what it may it will be a difficult habit to overcome in case these insects are bred in wholesale quantities.

Finally we must consider the enemies of the Odonata. In the egg state we have found a small red mite, an Arachnid, which skims rapidly over the water in

search of an Odonat egg, upon which it either deposits an egg, or excavates it for immediate nourishment. A minute Diptera, genus unknown, was also seen to overposit on the egg of Diplax.

In laying her eggs the dragonfly has always to guard against frogs, as we have already noted. In the larval state their enemies are considerably multiplied. Silvestoma, Notonecta and Ranatra and insects of that ilk all prey upon the young larvae: they in turn return the attention when they reach the latter stages. Forbes (39) points out their liability to attacks from fish. The fact that they are in this stage their

own worst enemy has been mentioned.

In the present dragon fly is said to be a common and a constant enemy of the birds; even they do not seem to select this food with much relish.

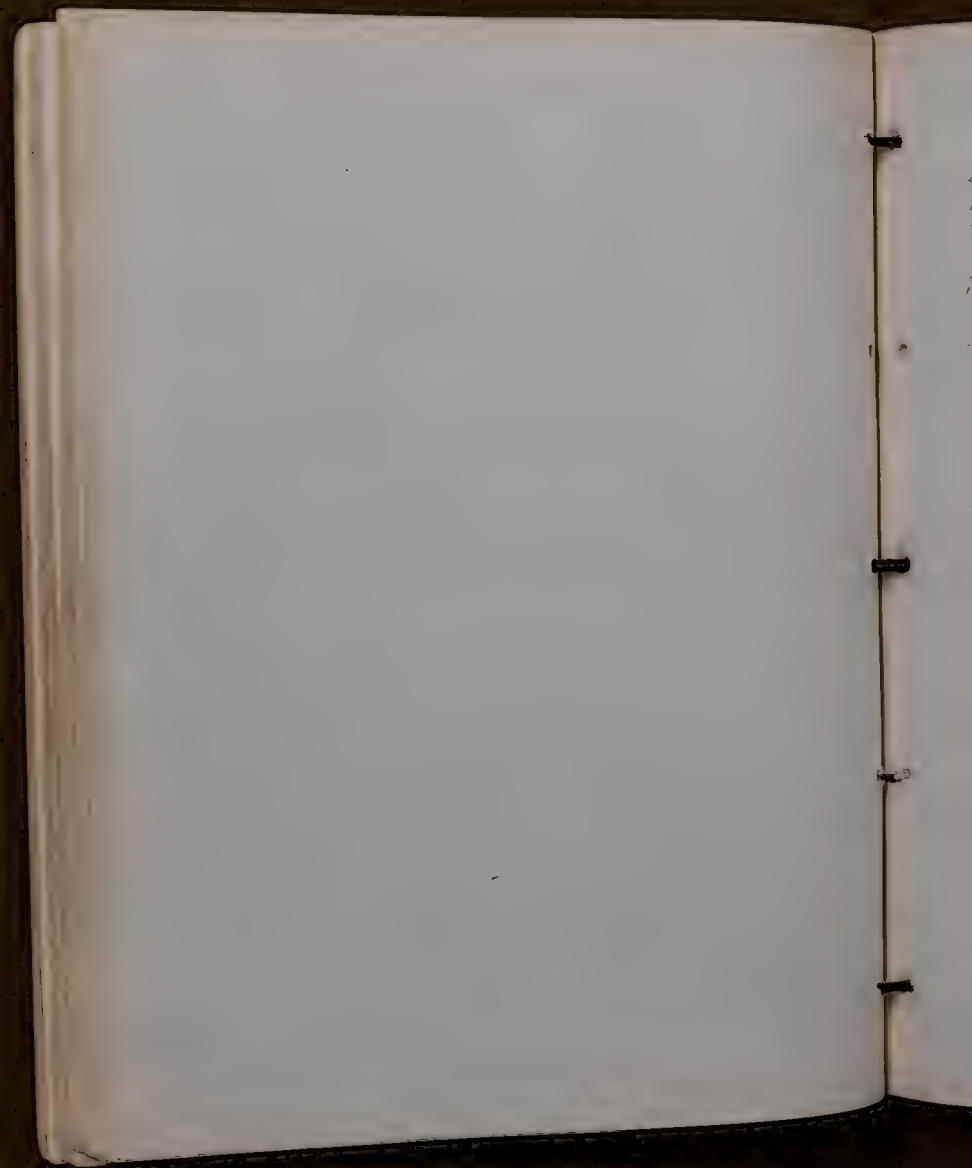
Barnes (54) considers them favorite food in the water, McLaughlan (94) believes these attacks only incidental, and Thomas (—) discusses the swallow in this capacity.



The Medical Problem.

The disagreement between the two schools of students relative to the annihilation of Culex and Musca seems to be an almost irreconcilable one with the present light which we now possess.

A large and eminent school of scientists believe it unsafe to overthrow the equipoise of nature, or, more properly speaking, that due proportion of individuals in the animal kingdom. They urge that nature has eliminated all useless



should be that there is a carefully des-
igning of any kind of time before we in-
troduce some function which will leave
us far worse off for the need of it.

But an equally numerous school
take the ground that it is incumbent
upon man to first ascertain the exact
nature of a disease, and at the same
time as in his judgement may seem
best. With such creations as the Canada
Thistle, the Potato-beetle or the Colorado
grasshopper, we have held no fancy.

Without stopping to question its nature,
in the economic situation, they simply
treat such pests as unadvised evils to be
exterminated as quickly as possible.

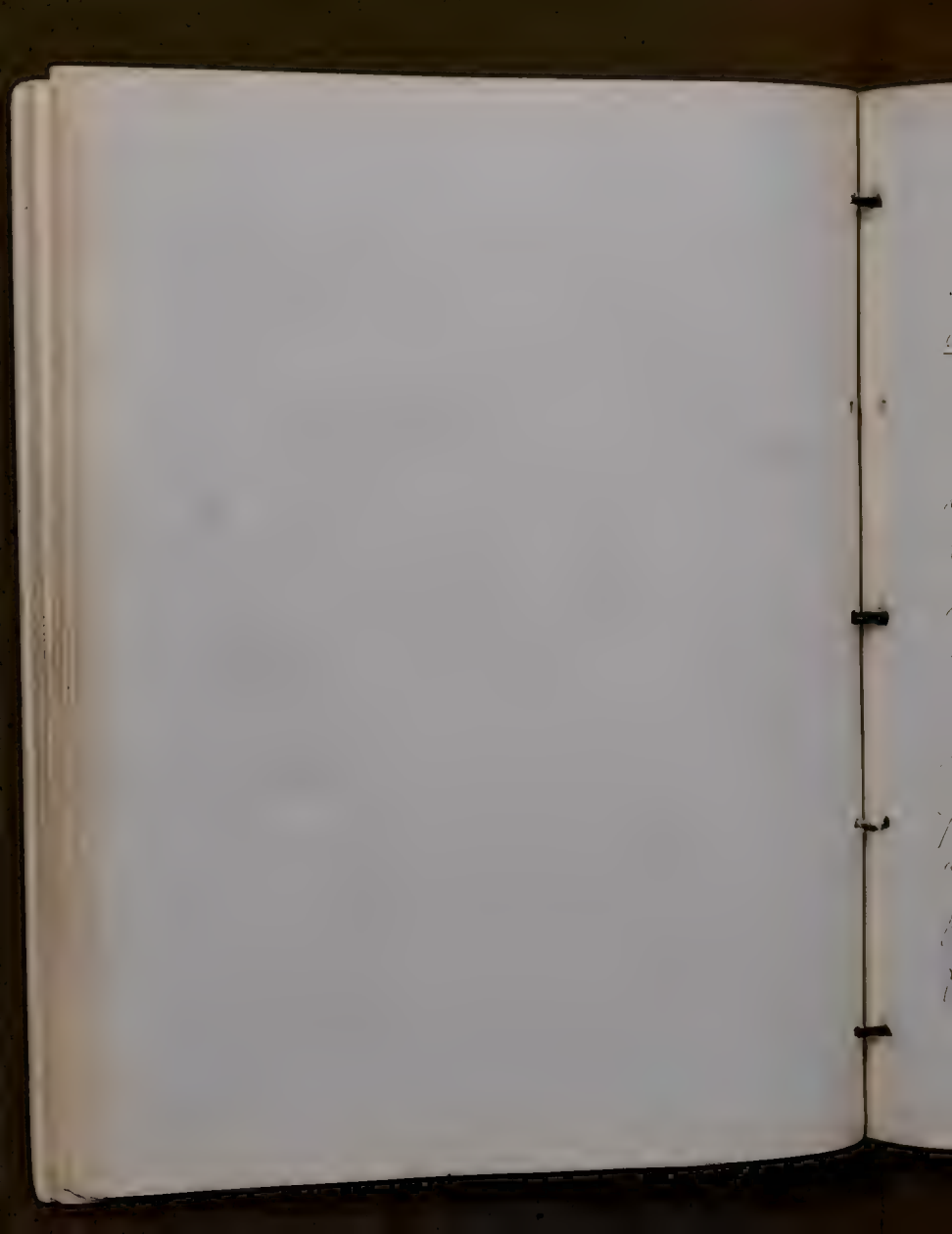
gladly risking the effects of the outrage
thus offered, that the great evils worked
by the species may be remedied.

Within the mosquito or house fly
it is to be treated as an evil, it is hardly
possible to decide if the more numerous
relations of the house fly could be elimin-
ated from it and proceed against
as a distinct class the problem would
be capable of solution.

The obscurity of the ac. having
to do with human parasitism and
the difficulty of following the feeding
habits of the mosquito and fly in na-
ture; make it very difficult to come
to any definite conclusions. The medical

literature on this subject is too conflicting
to guide the student in forming a rati-
onal judgment.

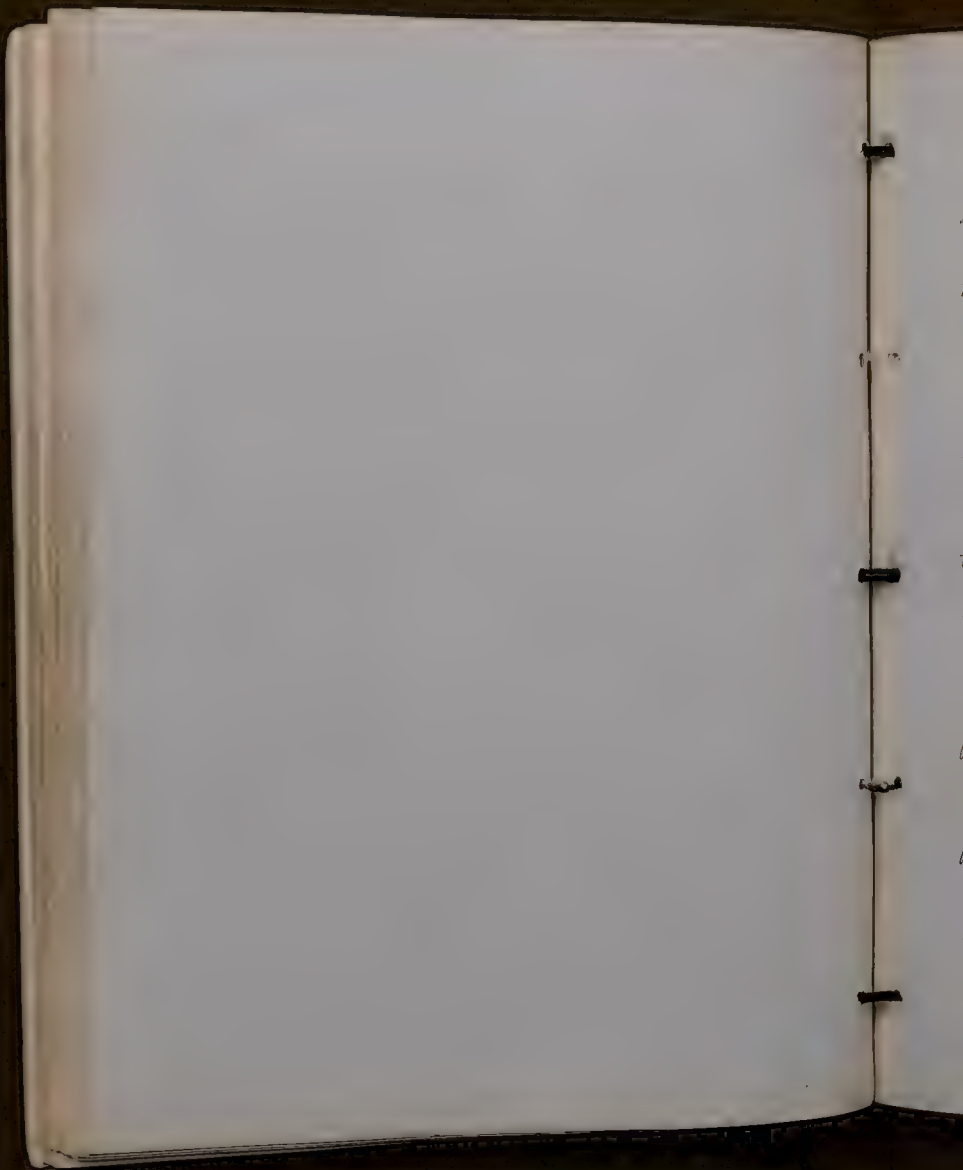
The principal charges against
Lucy are as follows: (1) Its host is an
unalloyed host in the imago state, by
reason of its acquired fondness for human
blood. (2) It is a harbinger of Hæmatozoæ,
and consequently a constant menace to man
by virtue of the fact that as host of these
dread enemies it helps them towards a period
of development where they become a serious
visitant in the human system. (3) It is ar-
gued that if it can harbor and transmit
such diseases as arise from Filaria and
other forms, it may also be the means of



inoculation and its nature and other dis-
eases. In other words, the *W. filaria*
sanguinis-hominis can be passed into
Culex, the far smaller genus believed
to be the prime cause of these other
diseases can easily be transmitted in
the same way or by the more direct
method of inoculation by puncture
with the proboscis.

There is room for much useful
research in this *W. filaria* problem. Our
present knowledge may be epitomized
as follows: Lewis (73) has found twenty
female mosquitos out of a hundred and
forty, to be infested with *Waimatogoa*,

McCleod, commenting on this, states that



the diseases arising from Filaria in the blood
"are very serious." Manson (86) estimates
that the blood of one man may at one
time contain at least 2,000,000 embryos
Filariae. As the individuals of such a
brood could not attain any size with
in one human, it becomes necessary for
them to have an intermediary host or
"nurse", as it has been termed. In this
capacity Culex is said to act: the theory
further calls for the death of Culex and
the taking into the human system the
further matured Filaria through wa-
ter in which Culex has died. Manson's
experiments are interesting. They are
commented on by Dr. Cobbold, who



was strongly impressed. Sorsino (154) has also written on this theory.

King (61) has, in a very notable way brought charges against Culex as the cause of malarious diseases. He reasons on the fact that mosquitos are found where malaria abounds. It seems to us, as it does to Stebbins (157) that the reasoning should have proceeded in the reverse direction. Malaria and Culex are widely separated at the Sea Shore, as many can testify, who leave their city homes to escape the former, and are persecuted by the latter.

Liegard narrates the symptoms produced by Culex funebris in France.

and an account of the serious effects of an unknown species in the city of Mexico is given in Science. (182).

Vague and unsatisfactory as these charges seem to be, they are sufficiently suggestive as to warrant greater attention than they have yet received.

Against Musca, we find much graver charges and more direct evidence.

The published researches of Grassi (43) have been of recent years, the most important and those on which other papers have been based. Packard (113) abstracts the above and states that they "go to show that flies are agents in the diffusion of infectious maladies,



epidemics, and even infectious diseases."

Crassi's experiments consisted principally in placing the eggs of a human *hematoid* (tape worm) parasite, on a plate from which the flies sucked them up^{as} they were found on the excreta spots on sheets of white paper hung up for that purpose. The same results were obtained with the ripe segments of *Tænia solium*, another tape worm.

"E. P. W." (176) reviewing the discoveries and speaking of the fly's food says:
"It may be the expectoration of a phthisical or the ejecta of a typhoid patient; but irrespective of the material, their next visit may be to the moist lips or

eyes of a human being." He adds: "It seems scarcely doubtful that in Egypt, ophthalmia is constantly earned by such winged visitors." Taylor (160), Girard (122), and Seidy (29) record instances in which flies have spread gangrene and other diseases.

The main disease, Musca domestica with a fly in its beak, that as a well known scavenger, it is far too useful to man, to warrant its extermination without mature deliberation.

Leaving the sucking group and coming to the biters, we have to deal with a very different state of things.

Stomoxys calcitrans is the species of

the biters in which is most frequently taken for Domestica, as it is a common visitor in our houses. It is referred to on page 39, and its prolegs are illustrated on plate 3, fig. 4. Riley and Howard (1835) bear testimony to its powers as a biter. Akin to it is the recently imported horn-fly, Hæmatobia serrata, plate 3, fig. 1, which has been quite common in houses during the rainy season this fall; we apprehend that it will soon be one of our "houseflies."

Antirax, or malignant pustule, a disease much dreaded in certain countries, has, according to Macleay (80), been traced to the bite of an unrecorded species

of fly which has feasted on animals dead from Splenic fever, Anthrax, Charbon or Cumberland disease, all names for one malady effecting cattle.

Bacillus Anthracis, the organism which is the cause of the disease," says Macleay, "is most tenacious of life; it has been known to retain its vitality in dried bones and skins for years. Where a carcass has been buried a depth of twelve feet, the Bacilli will in course of years find its way to the surface in the bodies of earth worms." On the other hand Taschenberg believes that Anthrax is not conveyed by flies; both sides are in need of much added research.



Various species of Hyperderma
larvae are occasionally addicted to in-
flicting serious but humanely inflicted
the most animals seem to suffer most
and deeply. Hyperderma bowi, plate 3
fig. 2 is supposed to be the species which
(Ill. 13) found under the skin of a man
who had been bathing in a stream
running through a pasture; the symp-
toms caused by these insects are called
"warbles" or "bots." Schöylen (1805), Osmerod (1804)
and others allude to similar attacks.

Of the same origin is the disease
known as "Myiasis," caused by the screw
worm the imago of which is Wacillaria
hornivorax plate 3 fig. 7 (Marsili,

Low (75) and Williston (179) all remark on this disease. Snow (183) gives full details of our present knowledge of this verminous species. Alatas (87) says it is the habit of this insect to fly suddenly into the ear nose or mouth or light on a sore and quickly deposit a few eggs; these soon hatch and the screw like worms, Plate 3, fig. 7. begin at once their task of eating away the tissues until removed or the death of the patient.

An occasional fly gets into the human nose or ear, Laboulbène (65); but this is so infrequent as to indicate that it is probably as much a surprise to the fly as to the victim.

Maddox (64) finds that a bit of sugar, well saturated with a bacillated fluid, is placed in the reach of flies, they will partake of it, and be attacked with violent dejections, in which bacilli will be found in motion.

Anthrax rods, (Sacillus Anthracis) were also taken up in the same way. Bailevi (1) and Faries (3^d) have each written of the susceptibility to inoculation by bacilli. Schoch (144) and Kaschenburg have treated of these insects as the cause of malarious diseases.

Williams (178) queries whether it is not better to bear these evils than to run the risks incident to their removal.

Riley (128) shows how easy it is to mistake a useful scavenger for a harmful parasite.

The sudden appearance in our localities and the injurious habits assumed by certain species are illustrated by Riley and Howard (186) in the case of the horn fly, the mosquito, *Cicero* (182), and the *Pitiless* gnath (Buck (10).

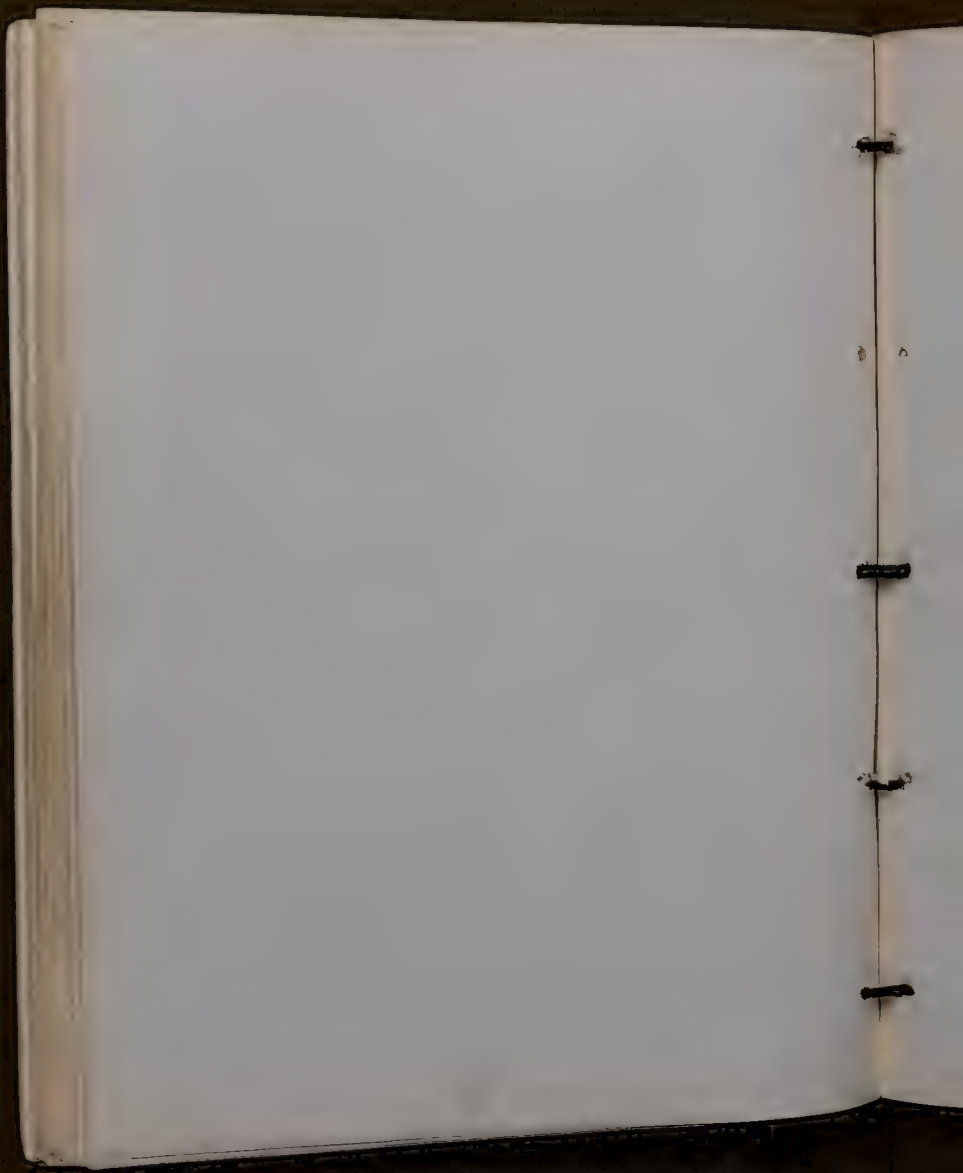
Praver (9) treats of *Cestus*, and its attacks on man, bibliographically; Jacobsthal also writes of these insects.

Cephus have frequently been cast up by vomiting. Laboulbène (66), Packard (114).

Spicer (155) has published and illustrated, interesting material on human-

first noting this

The foregoing, but a brief indication of what has been written, will give the reader an insight into this most interesting history of medicine and medical science. A full bibliography of the subject will be found in the Catalogue of the Library of the Medical Surge General.



The Possibilities and Costs.

The insecticide substances and other means for arthropod extermination now known to Economic Science are legion. An acquaintance with their properties, and a knowledge of the experiments which have been made with them, require years of study and research. It is not our design to treat of the methods of the work already done, or the nature of most of these remedies. A fair understanding of the former may be obtained by consulting Comstock (18) and the latter by referring to Riley (124-132).

There are some insecticides which
can best be discussed at this time. They
are substances as well as their union with
water, dust or larval life. Chief among
these is the well known Lime or
"lime" insecticide. That it is one
of our most important insecticides, may
be judged from the fact that it is
it is all our Government reports. But
it is for the purpose to be of practical
value in the cases now under our consid-
eration. To mix it in ponds or pools
or heaps of compost in sufficient quan-
tities to overcome dipterous larvæ, is quite
beyond our calculations. To attempt to
use it against the adult fly or mosquito,

is equally voracious. Various insect
icides which come next in importance,
are well adapted to the conditions in
which larva Culex and Musca are to
be found, are: Naphtha, Sulphurous exha-
lations, Chlorinated water, and Naphtha
lime. None of them however are sufficiently
cheap or easy of application to answer
our purposes. The reader may consult
Cornelius (19) Riley (129) Kra. n. afi (44) and
Vol 93. In preparing the nature of
the above, and their cheap and ready
application, Petroleum in its various
dilutions, may be given a very important
place in this list. Its many qualities
commended themselves to us early in our

search after the *Passimilis* and the great measure of success met, will be discussed further on. Petroleum

compounds have had favorable mention from several writers in our bibliography, *notably* Correns, 19 *ibid.* 126, 127 and West (93).

Leaving the inorganic insecticides, we come to a class of vegetable poisons belonging to the fungoids. Here we find at once, a most difficult, yet, *horrific* and one that seems to me to be a more *horrific* one than any we explored. As an introduction to this subject we may mention that classic of sci. type, *recurrence* by Quat. (115) on the diseases of the silk-worm.

So suggestive is this work, leading to a
new thought, that it is surprising to find
how few of the many who have seen it
are in the shade of its possibilities.

The Entomophthorae, fungoid growths on
on insects, are undoubtedly a potential
class of insecticides, with great recupera-
tive and reproductive capacities, and are
seemingly so organized as only to need a
thorough introduction into a colony to
enable them to carry on their death-deal-
ing mission. Kagen (46+49) quoting from
the late Dr. Bail of Germany, asserts that
the common Entomophthora Musca, or
"fly fungus" is none other than the still
more common fungus of yeast fermentation.

It is also said to be identical with the one now in mind, so an aggregate is proposed. The number of makers 46, 117, 44. The fungus is considered upon this theory and is answered in the negative by G. Ratze (68) and Freslin (121) who also demonstrate that these fungus are not a real insecticide. On the other hand Lindy (70), Pasteur (115), Giard (41), Bessey (6), Constock (17) and many others are attributed to the deadly effect of the various species of the Entomophthorae.

All observers are familiar with the sight of a housefly fastened to a windowpane by a filmy fungus or cobwebby growth, or with a caterpillar covered with

little vegetable growths. Both members of this insect-killing group. Very little is known of the methods by which insects may be made to inoculate each other with these germs. Our own Bibliography must not be taken as an indication of the number of papers written on the subject, as we have only included a few, representing epochs in this research, and for additional literature we refer to Forbes' (38) most complete list.

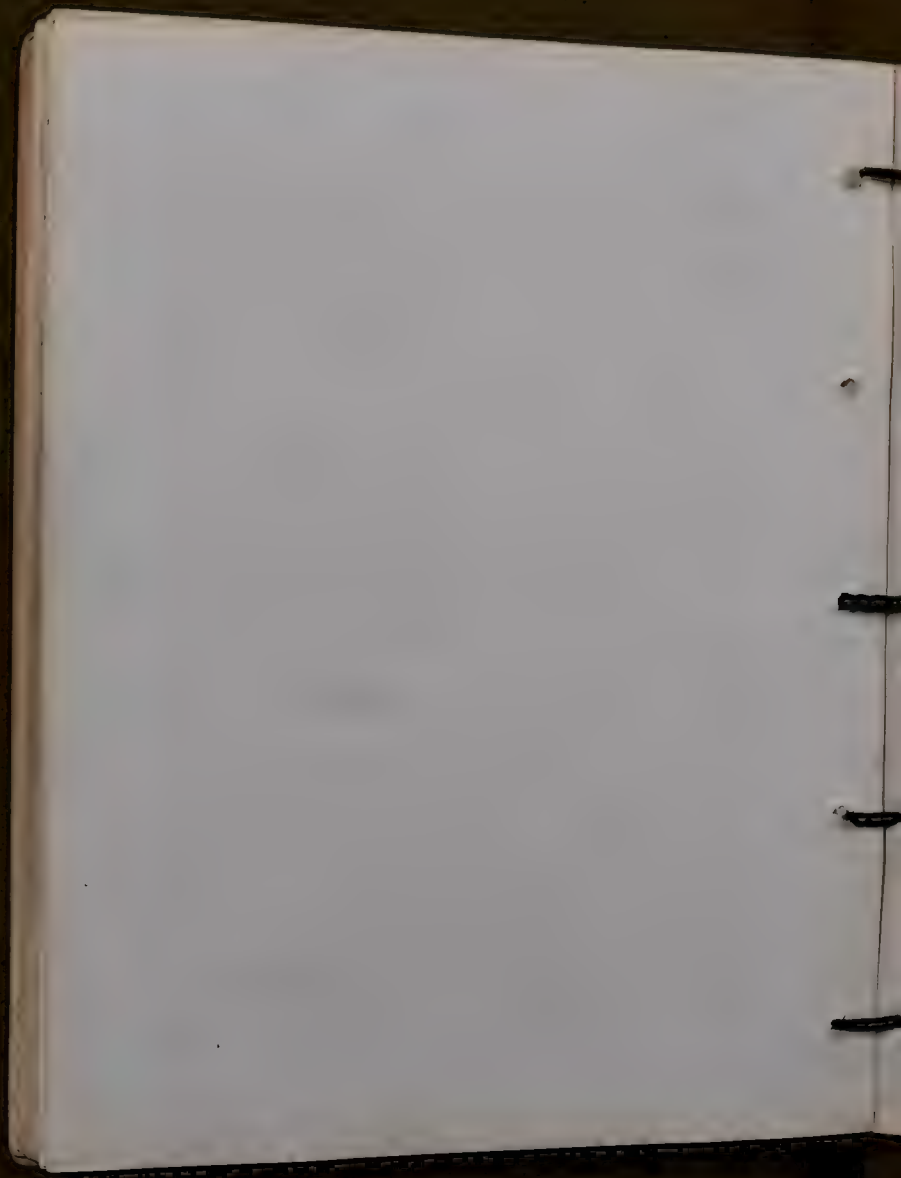
We regret that our experiments have been unproductive of anything new, and have contributed nothing to set at rest the dispute as to their effectiveness.

We believe that the propagation of such

forms as attack the house-fly, should receive more attention from experimenters; that is if the extermination of Musca domestica is to be regarded as a wise move.

Sackard (109) has pointed out that Nature's means of preventing the too rapid increase of insect life is largely through the medium of parasitic insects. There are several insects which belong to various families of Diptera now under consideration, but none of them to such an extent, as do the various species of the Odonata.

The preparatory stages of the Culicidae and Muscidae are passed under such widely diverse conditions, the Odonata will have to be considered under different heads.

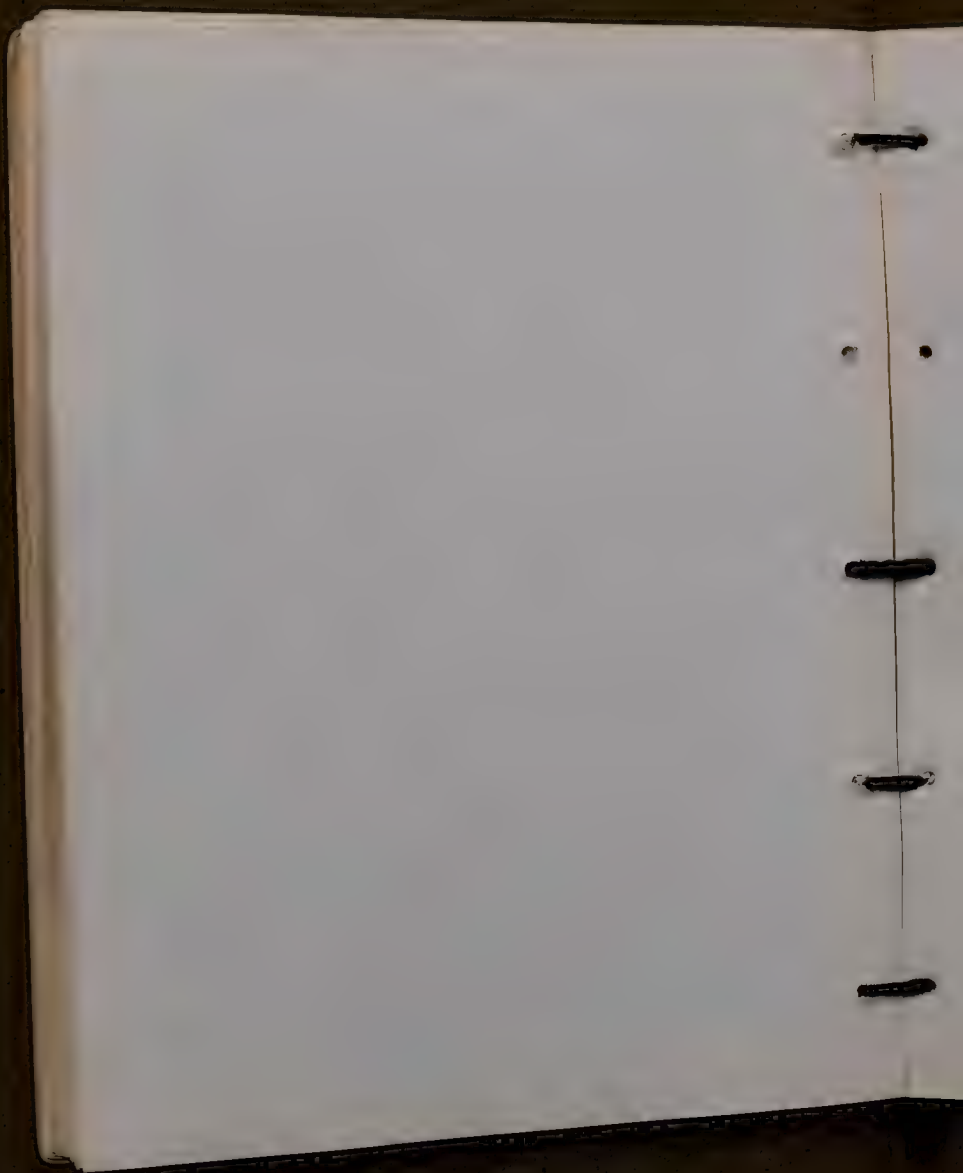


There are some cases in which the
insects are found in the same place
as the water, but in some cases they
are found in the mud and Thomas (139) has given
some illustrations in the case of other insects.

The multiplication of aquatic insects
is aided in the same proportion as the
land insects, and the same is true of the
aquatic insects. Culex or Stucca is a very
commonly distributed insect in this method.

Having discussed those insecticides
which are generally applicable to this
method of extermination we come now to
some special considerations to be taken
up in detail.

The Culicidae are much more



vulnerable in their larval state, and a consideration of their early stages yields several new points. The means for extermination may be divided into natural and artificial insecticides and destructive methods. Under the former may be classed all chemical or animal enemies, Aquatic Hemiptera and Coleoptera, Fish, Odonat larvae, etc. Of the latter class, flushing the breeding places with water, draining swamps, and creating active artificial currents may be mentioned. Aquatic predatory insects may be dismissed at once, while such have been observed to be inimical to the Odonata while in their earliest

siages, such genera as Notonecta, Ran
atria, Geoffria, et al do not bother the
selves with the slender Culicidæ which
lack substance and fulpiness.

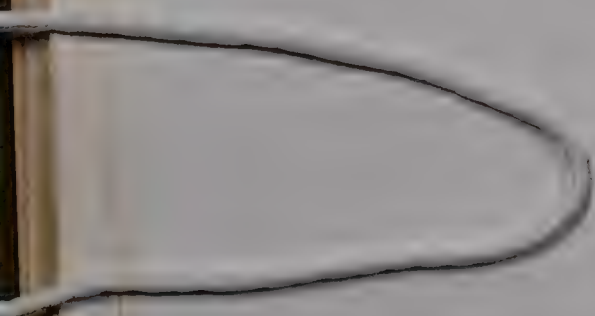
Fish are active and untiring in
their efforts to thin out the Culicid ranks.
A small surgeonfish taken from our aqua-
rium and put into one of our many
tanks of water well infested with these lar-
væ had soon to be removed as he re-
duced the ranks too rapidly. Unfortun-
ately it is seldom that fish can be util-
ized, as Culex usually selects for oviposit-
ion those pools and stagnant ponds
where fish cannot live. Where the
breeding ponds or marshes are near

the sea shore or inland bays, fishing
these pestholes will be found an ex-
cellent remedy. If plenty of rapidly
running water can be forced into these
places and cause them to overflow into
main waterways, the Culicids will be
devoured by minnows and other small
fish to a great extent. For this
purpose we would recommend wind-
mills. The farmer or neighborhood
where is annoyed by the proximity
of a mosquito rendezvous can buy and
if a windmill, pump the stagnant pools
into the stream, or if there be no near-
by running water the pools or marsh
can be drained to one point by dig-



ging a small pool at a lower level.

From this the water can be pumped and thrown back upon the land. In this way a circulation of rapidly moving water may be maintained, and in it Culex cannot live. In addition to ridding the neighborhood of mosquitos, this plan will also purify the atmosphere of much of the miasmatic influences which arise from swamps and stagnant bodies of water. The cost of draining and repumping the water on a tract of say fifty acres of swampy land will not exceed \$125.⁰⁰ at the outside. If such work is assumed by county or state commissioners it can be

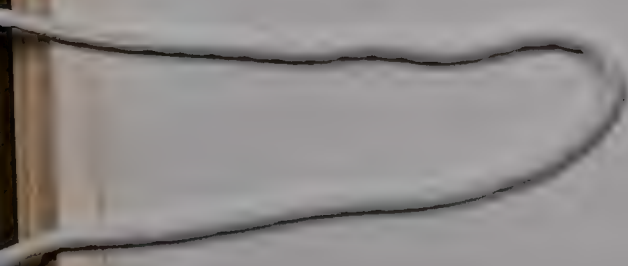


done at much less proportionate rates.

Where the area of mosquito breeding territory is large, it will be necessary to draw on a larger scale. Where the isolated ponds are near the sea, the waves may be made to communicate their resistless power to a large float, the rising and falling of which will set in motion the plunger of a mammoth pump.

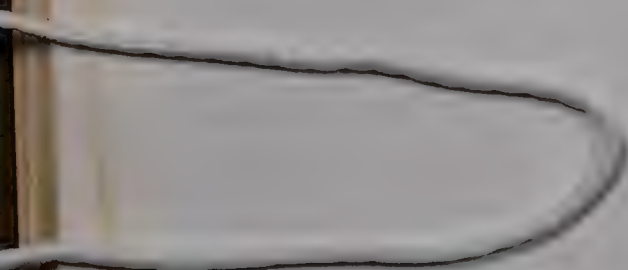
Very many swampy tracts may be filled in with earth. If this is done systematically in connection with these other methods, many a neighborhood now almost uninhabitable, will find a rising market.

In the imago state, Culex is much



more difficult to reach with destructive agents. ^{or} To prevent mosquitos from biting, various washes and decoctions have been well tried. Quassia water and oil of pennyroyal are strongly recommended. Outside of houses at night time, the principal enemies of Culex are probably night hawks, whiffling wills, and bats. Harvey (53) has found six hundred mosquitos in the crop of a night hawk, evidently these birds are worthy of encouragement.

We know that mosquitos are attracted to our houses by the illumination from within; therefore if lights are removed away from our habitations, in suitable localities near marshes and ponds



and arranged, as in Plate 6, fig 2, with petroleum in the tray, they are the means of destroying myriads of these tormentors.

Funoid growths have not been tried upon Culex; we observed however an interesting species of Algæ on the head of many larvæ.

The very few, using methods remain to be discussed, save the Odonat cultivation and the oil treatment.

The former is of the most importance from the standpoint of this essay, as it is the plan which brought forth the call for the contest. We regret that our careful and continued studies under all conditions and favorable

circumstances show that the habits of the Odonata remove them from the possibility of close contact with the Culicidæ and their tastes are such as to make the latter unsatisfactory food for them. However, with a view to the possibility that others may not look upon this problem as we do, we give the outcome of our experience, in rearing the Odonata. They must be kept in slowly running water and the tanks in which they are bred must be free from all aquatic predatory insects and so screened as to prevent the ingress of these or of frogs. Fish must be kept out and netting should be spread, so that birds



may not attack them when they emerge
from the pupae. Caring to their canni-
balistic tendencies, the larvae should be
placed in large tanks with a limited
number in each and fed carefully with
pieces of fresh fish. Allowing for five
broods of mosquitos in a summer and
that one hibernated female may be
responsible for at least 10,000 larvae
by the time the Odonats appear, it
will be seen that the one brooded em-
all need to be produced on an enor-
mous scale. Liberated in great quanti-
ties, as they would be if bred in suffi-
cient numbers, the dragon flies might mi-
grate to less crowded localities.



The question of transporting the young larvae from the breeding tanks to the mosquito infested ponds is to be considered; although they are tough and can stand jostling, only a few can be carried in one receptacle. Twenty put in one jar would be found to be an inextricable kicking mass of cannibals after a mile's transportation.

We have failed to find the natural enemy of the mosquito, to be the dragon-fly, and have intentionally reserved to the last, that remedy which to us seems to far outrank all others of which we have any knowledge or have been able to devise, viz. the oil treatment.

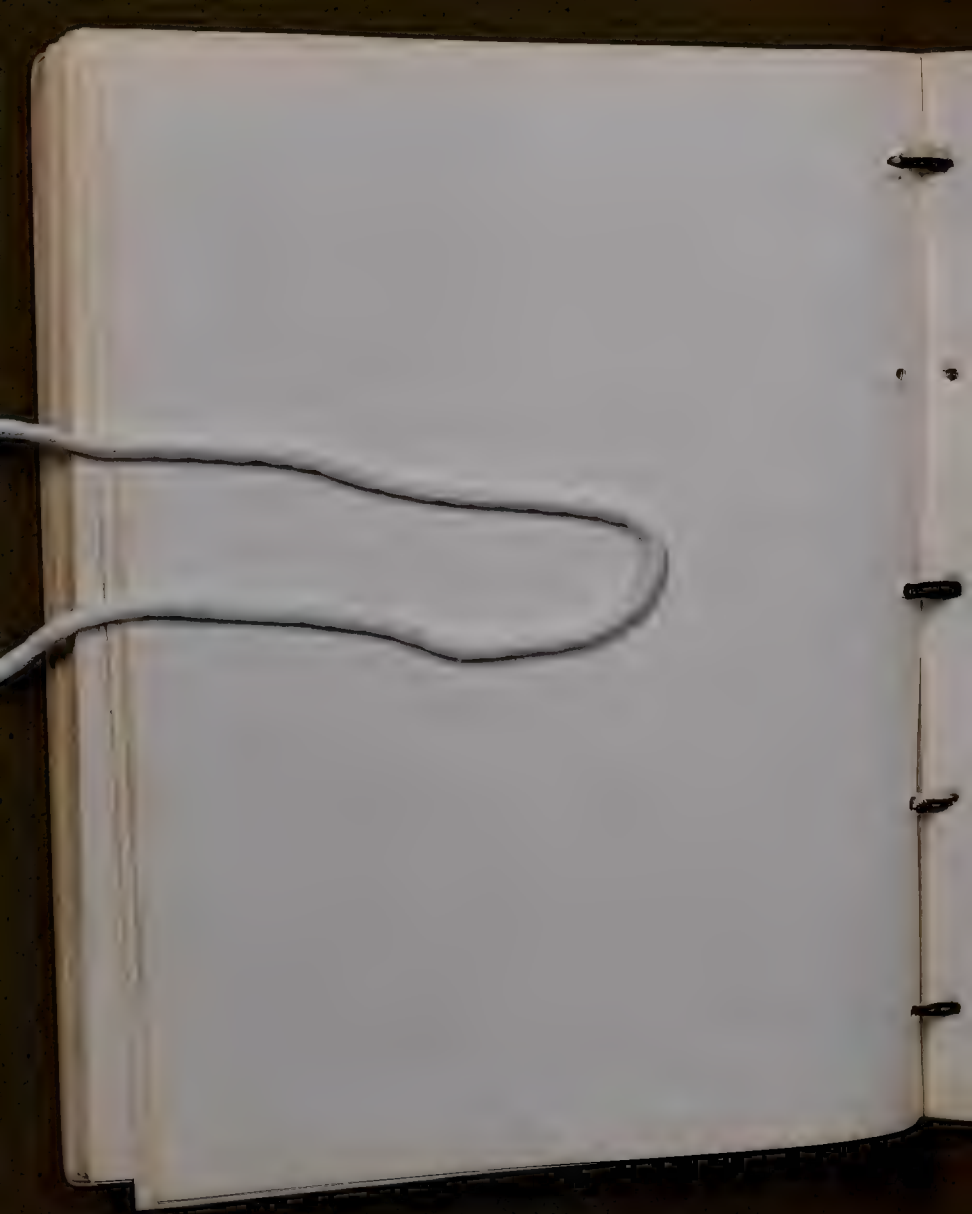


The U. S. Department of Entomology and the various State Reports as well as numerous economic entomologists abroad have long recommended the use of petroleum in some form for the extermination of plant lice and many other noxious insects. Petroleum emulsion, sprayed petroleum, the naphtha compounds and others from the same source are prompt and deadly insecticides. With this in mind we early began a series of tests with common illuminating oil on *Culicid* larvæ, under all circumstances. The narration of one series of experiments, typical of all, will illustrate the efficacy of this



treatment. Into a shallow pool of water with an area of ten square inches, five pupae, two grown larvae and about sixty others in various stages of development were put. With them were also two immature Odonats, and a number of Cyclops and Bythotrephes. On the surface ten drops of oil were placed and were observed to cover the entire area in ten minutes. At once great uneasiness was manifested by the larger larvae, then they all began cleaning off the breathing tube with their jaws, with apparent discomfort.

The very evident effect of the oil was to coalesce the cilia at the tip of the tube, thus making respiration difficult or im-



possible. The annoyance, fear, agony and finally, desperate frenzy were clearly depicted by their actions. The two grown larvæ were dead in eight minutes; several of the halfgrown died in ten minutes; at the end of twelve minutes, most of the remainder save the very smallest had succumbed. The pupæ had both expired in fifteen minutes. In an hour and a half everything was dead except the Odonata and minute crustaceans; the former seemed to be in perfect condition owing to their multitudinous breathing appliances. After the oil had been put on the above area, it was at once seen that the proportion was too great. A



second pool, of the same dimensions, was tried with one drop of oil, which was quite enough to have the same deadly effect, though the results were not so rapidly attained. The allpervading nature of the oil was shown by the fact that one of the larvae removed to a pool of eight square inches of surface took enough oil with it to cause almost instant uneasiness to the inhabitants of the otherwise fresh water.

These experiments were tried time after time, always with the same result, and show conclusively to us that oil is the great hope of nearly every mosquito infested district, for the following reasons:



(1) Its cheapness; (2) Its deadly nature when applied to the Culicidæ; (3) Its comparatively harmless nature as applied to other forms of aquatic life; and (4) The ease with which it can be applied.

Of the first claim we only care to say that \$3.00 worth of the crude oil will suffice, according to our estimate, to cover an area of one hundred acres of water surface, five times in one season. In this way every brood would be greatly retarded or entirely destroyed in that area. In illustration of the second claim we may state that mosquito larvæ lived as long in pure Brown's Jamaica-Ginger as they did in water covered with a film



of oil. The depth of water does not count: Culex must come to the surface to breathe.

If the oil is sprayed, as illustrated in Plate 6, fig. 1, it need not interfere with the herbage. Odonat larvae will not be found in stagnant water, and fish must have fresh water, but oil may be carefully sprayed over any surface however small. The tube may be attached to a festoon pipe, in order that a spray may be thrown some distance. A Kiley or Cyclone nozzle is best adapted to this purpose. In closing this account of Culicicides it is well to call attention to a paper by Bogil (26) in which a description of twenty-two poisons on Culex are given.



The possibilities for destroying members of the Muscidae are not so promising as are those of the Culicidæ, owing to their hidden habits and the repulsive nature of their breeding places.

Under the discussion of general insecticides at the beginning of this chapter, the treatment of Pyrethrum gases, certain parasites, yeast and other fungi have special bearing on the fly problem.

As it appears to us, the only very promising methods are, cultivation of fly fungus and the oil treatment.

On page 88 will be found a resume of the present knowledge of the subject of fungoid growths likely to effect the fly.



The application of oil can only be made during the larval and pupal stages.

Spraying petroleum on compost heaps and other breeding places will be effective.

The methods of applying are described on page. We believe that, after much study and experience, the Edonata can not be considered a formidable enemy. The method of breeding them however has been described on page. 100.

A Final Summing Up.

To gather together the weight of the testimony in the foregoing chapters and to clearly set before the reader what in our opinion may be the best



exterminators to use against Culicidæ
and Muscidæ in their various stages,
we close with the following table.

Culicidæ: Larva and pupa.

- 1st - Sprayed petroleum.
- 2nd - Flushing, circulating, grading.
- 3rd - Odonat culture.

Imago.

- 1st - Pennyroyal vapors
- 2nd - Odonat culture.

Muscidæ: Larva and pupa.

- 1st - Sprayed petroleum.

Imago.

- 1st - Cultivation of fungoids.
- 2nd - Odonat culture.



The compilation of a bibliography including papers produced in the domain of Medicine, Biology, Insect Classification and Economic Entomology is not the work of a day nor the outcome of a simple searching in the index of one or a dozen standard authorities. Nor does the mere enumeration of a list of the leading text books suffice, for the bulk of the literature is found scattered through the pages of the scientific periodicals of the last twenty-five years. The Zoological Record and Zoologische Anzeiger have been invaluable aids in



this work. It has been necessary to look carefully in books, and papers where the title afforded the least hope that pertinent matter would be found. It was not however, alone difficult to compile this list on account of the scarcity of works having reference to the subject, but it was quite as perplexing to eliminate from the list those references which were either duplicates or such as were condensed from more comprehensive productions. It may be urged against this list that too much has been excluded, but in order to make it of the greatest possible worth to students, writings of the following classes have been eliminated

1st. Pertaining to distribution, migration



and works in countries very remote from the United States.

2nd. Abstracts of papers already published in more accessible forms, or abstracts in languages not so generally read, as that in which the originals were published.

3rd. Publications of a popular nature, in which the information is given at second-hand, and not in such a way as to make it as accessible as others of a similar nature.

4th. Publications in languages such as Russian, Dutch, Hungarian, Scandinavian, et al., and which have been abstracted in papers more accessible to all.

It is believed that all separate papers or works which have a direct bearing on this



general subject, and which are not ruled out by the foregoing rules will be found in the list, if they were published during the last twenty-five years. In selecting papers of an earlier date, greater freedom has been taken in rejecting such as seemed purely introductory and elementary. The combined results of most of these are now found in our standard text books on the Classification of Insects.

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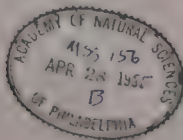
Description of new cattle pest (see 186).



Dr. Skinner

Congratulations

1890





DR. HENRY SKINNER,

716 NORTH 20TH ST.,

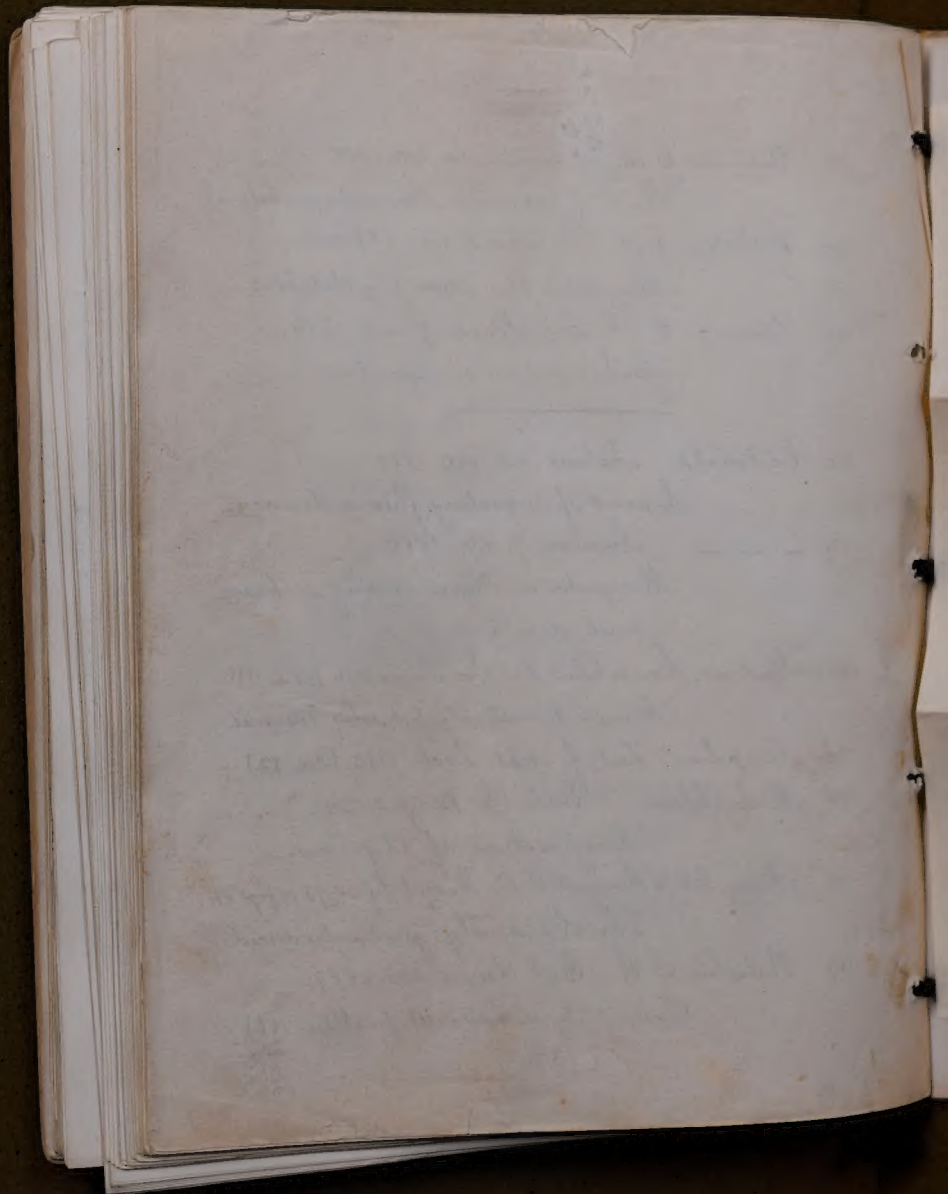
PHILADELPHIA.

4/5/90

Dear Mrs. Aaron,

I sincerely congratulate you and
am heartily glad you received the prize
although it is nothing more than I pre-
dicted. Your entomological reputation will
now be well established and it will
help you in the career you have map-
ped out.

Very Truly Yours
Henry Skinner.



Dr. Sinners Congratulations

I received
Congrat -

